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ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)

DEC 74 DACW67-73-C-0022

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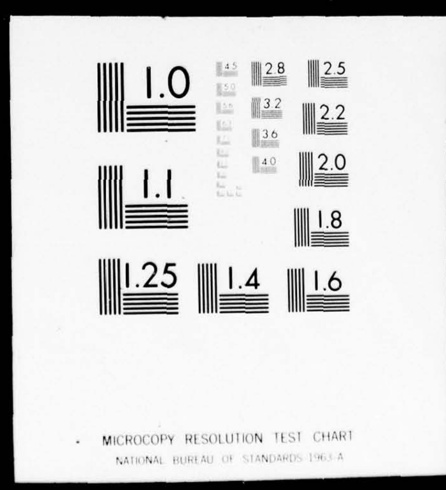

Environmental Management for the Metropolitan Area
Cedar-Green River Basins, Washington

Part II
Urban Drainage

Appendix A

Regional Sub-basin Plans
Volume 2
Green River Basin

December 1974

U. S. Army
Corps of Engineers
Seattle District

(6)

ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA

CEDAR-GREEN RIVER BASINS, WASHINGTON

Part II. URBAN DRAINAGE STUDY

(1)

APPENDIX A

REGIONAL SUB-BASIN PLANS

VOLUME 2. GREEN RIVER BASIN

RIBCO LAND WATER WASTE

(11) Dec 74

Technical Direction by

(12) 381p.

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(15) DACW67-73-C-0022

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Consulting Engineers

KRAMER, CHIN & MAYO — WATER RESOURCES ENGINEERS

YODER, TROTTER, ORLOB & ASSOCIATES

December 1974

410 300

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RIBCO TASK FORCE FOR CITIZEN PARTICIPATION

Shirley Farley, Chairwoman
Brad Collins, Vice-Chairman

Dale Ashley	Kay Johnson	Marion Sherman
Roy Avent	Henry Keron	Jerry Tucker
Jay Becker	Jack Locke	Jeanette Veasey
Don Beuthin	Ted Mathison	Forrest Walls
Larry Hall	Michele Meith	Bernice White
Edwin Hendrickson	Bob Porterfield	Ann Widditsch
	Stew Sargent	Lon Woodbury

RIBCO URBAN DRAINAGE TECHNICAL REVIEW SUBCOMMITEE

Roy Avent	David Glaze	Michele Meith
Phil Buswell	Robert Gulino	Marvin Seabrands
Harvey Duff	Dick Hibbard	George Wannamaker
	George Hsieh	Jim Webster

MUNICIPALITY OF METROPOLITAN SEATTLE

Nancy Baggott	Pat Levine	Richard Page
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KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS
YODER, TROTTER, ORLOB AND ASSOCIATES

Ark Chin	President – KCM
Ron Mayo	Executive Vice-President – KCM
Larry Rugaard	General Manager – YTO
Gerald Orlob	President – WRE
Roger Fry	Project Manager
Dick Warren	Deputy Project Manager

U.S. ARMY CORPS OF ENGINEERS

Colonel Raymond Eineigl	District Engineer
Sydney Steinborn	Chief, Engineering Division
Richard Sellevold	Chief, Planning Branch
Dwain Hogan	Chief, Urban Studies Section
Walter Farrar	Study Manager

PREFACE

This report is an appendix to the Urban Runoff and Basin Drainage Study. It contains general information on each of the regional drainage sub-basins within the Green and Cedar River Basins (State of Washington Water Resource Inventory Areas 8 & 9) and specific descriptions of all alternative drainage plans considered, including costs and environmental assessments.

The Urban Runoff and Basin Drainage Study is part of an environmental management program for the Green and Cedar River Basins in King and Snohomish Counties, Washington, and has been conducted under the auspices of the River Basin Coordinating Committee (RIBCO). Four principal studies comprise the RIBCO Environmental Management Program: Part I - Water Resources; Part II - Urban Drainage; Part III - Water Quality and Part IV - Solid Waste.

The Urban Runoff and Basin Drainage Report presents a comprehensive plan for meeting the existing and long range urban drainage needs within the Green ~~and Cedar~~ River Basin~~s~~. The study recommendations address drainage facilities, capital cost, methods of financing and institutional arrangements for effective drainage management. The recommended plans are conceptual and are intended for use by local governments as a guide in the future planning of drainage systems.

The published report is composed of the following documents:

Technical Report

Appendix A - Regional Sub-Basin Plans

Volume 1 - Cedar River Basin
Volume 2 - Green River Basin

Appendix B - Urban Storm Drainage Simulation Models

Appendix C - Storm Water Monitoring Program

This report is submitted in compliance with the terms of contract DACW67-73-C-0022 between the Seattle District, U. S. Army Corps of Engineers and KCM-WRE/YTO.

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* At the lower right corner of each sheet there is a sheet number. Letter designation "a" next to the sheet number indicates a problem area map; "b", "c", "d" and "e" designations are for alternative plans. Sheets without a letter designation indicate there are no problems or alternative plan features thereon.

PRESENT DRAINAGE SYSTEMS

NATURAL SYSTEMS

The underlying and basic drainage system within the Green and Cedar River Basins is a complex of streams, rivers, lakes, ponds, wetlands, and Puget Sound. The Urban Runoff and Basin Drainage Study has focused on 27 regional sub-basins and their stream systems, although numerous other named and unnamed streams make up this system. The two major river basins, the Green and the Cedar, have origins in the snowpack of the west slopes of the Cascades. The remaining stream courses and water bodies, while receiving precipitation in the form of snow, are primarily dependent upon rainfall as their source of water. The significant rainfall occurs from late fall to early spring. While winter flows in the streams are usually higher, perennial flows are experienced by all streams serving a drainage area of approximately 1.5 square miles or more. The wetlands and ground water stored in permeable soils provide the main source for summer flows.

The lush natural vegetative cover of the region has an annual capability for returning water to the atmosphere through evapo-transpiration in excess of the amount of precipitation that actually falls.

SEMI-DEVELOPED SYSTEMS

Every stream system has some type of man-made improvement. All streams have at least a few culverts and bridges and the sub-basins in which the streams are located have some impervious surfaces such as roads, houses, businesses, etc., many of which are drained by conduits to nearby watercourses.

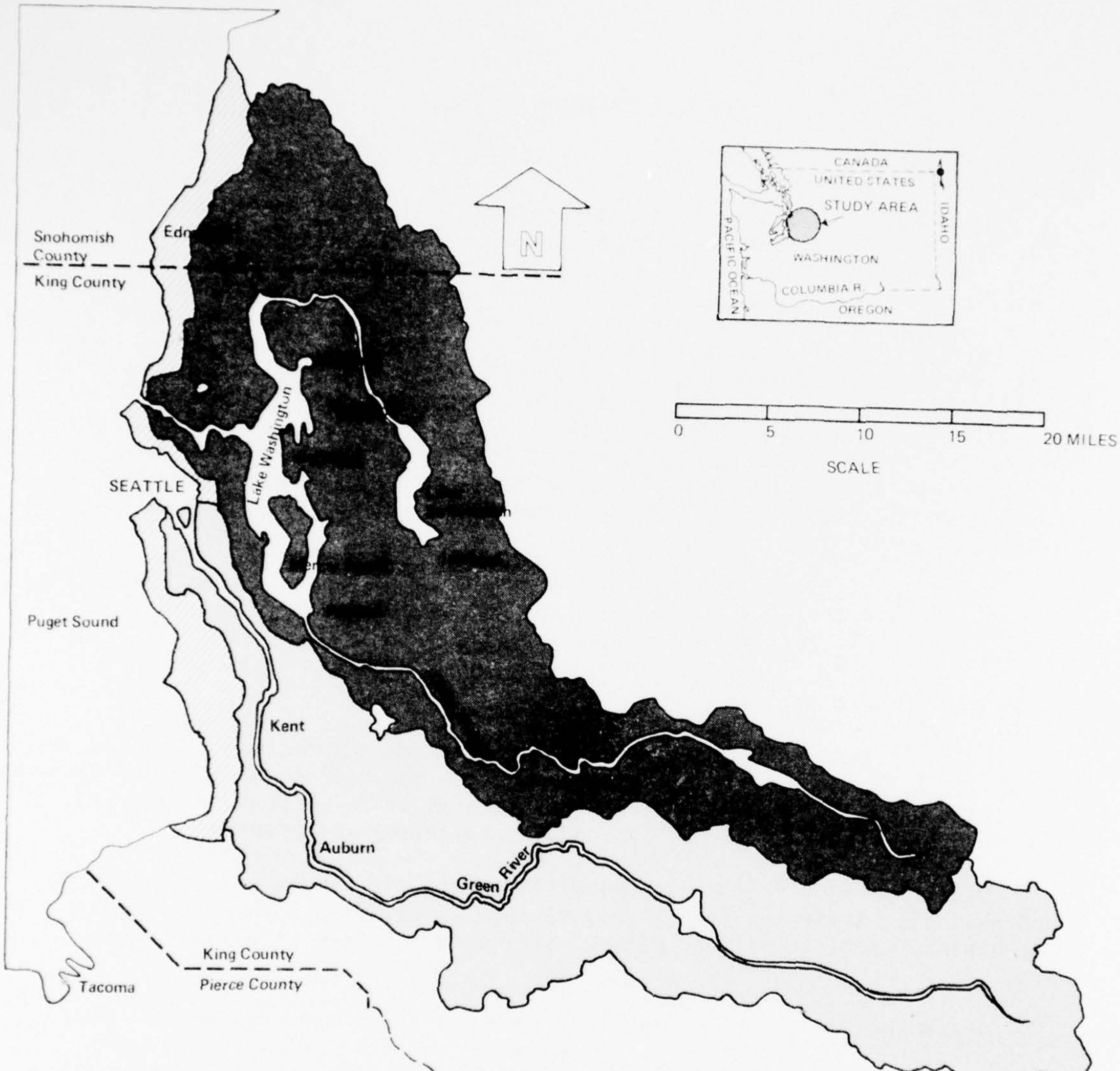
Other man-made features commonly found are rip-rapped and concrete-lined channels, diversion structures, storage ponds, fish ladders, gutters, catch basins, settling basins, weirs, water-supply intake pipes, and reservoirs.

These additions to the natural drainage system have been made primarily as urbanization of natural and rural areas has occurred. These have been made because the very process of urbanization has so altered the runoff characteristics within the watersheds that the streams need to be controlled in order to prevent major flooding, erosion and siltation.

While some of the changes to the natural streams have not resulted in any significant adverse impacts, the net effect of continuing changes is a steady degradation of the natural stream system. This degradation has progressed to the point for some streams that significant fisheries resources have been lost, annual flooding is commomplace, and summer flows have become non-existent.

FULLY DEVELOPED SYSTEMS

When a stream channel can no longer withstand the rapid runoff attendant with advanced urbanization, it is often completely encased in a pipe or



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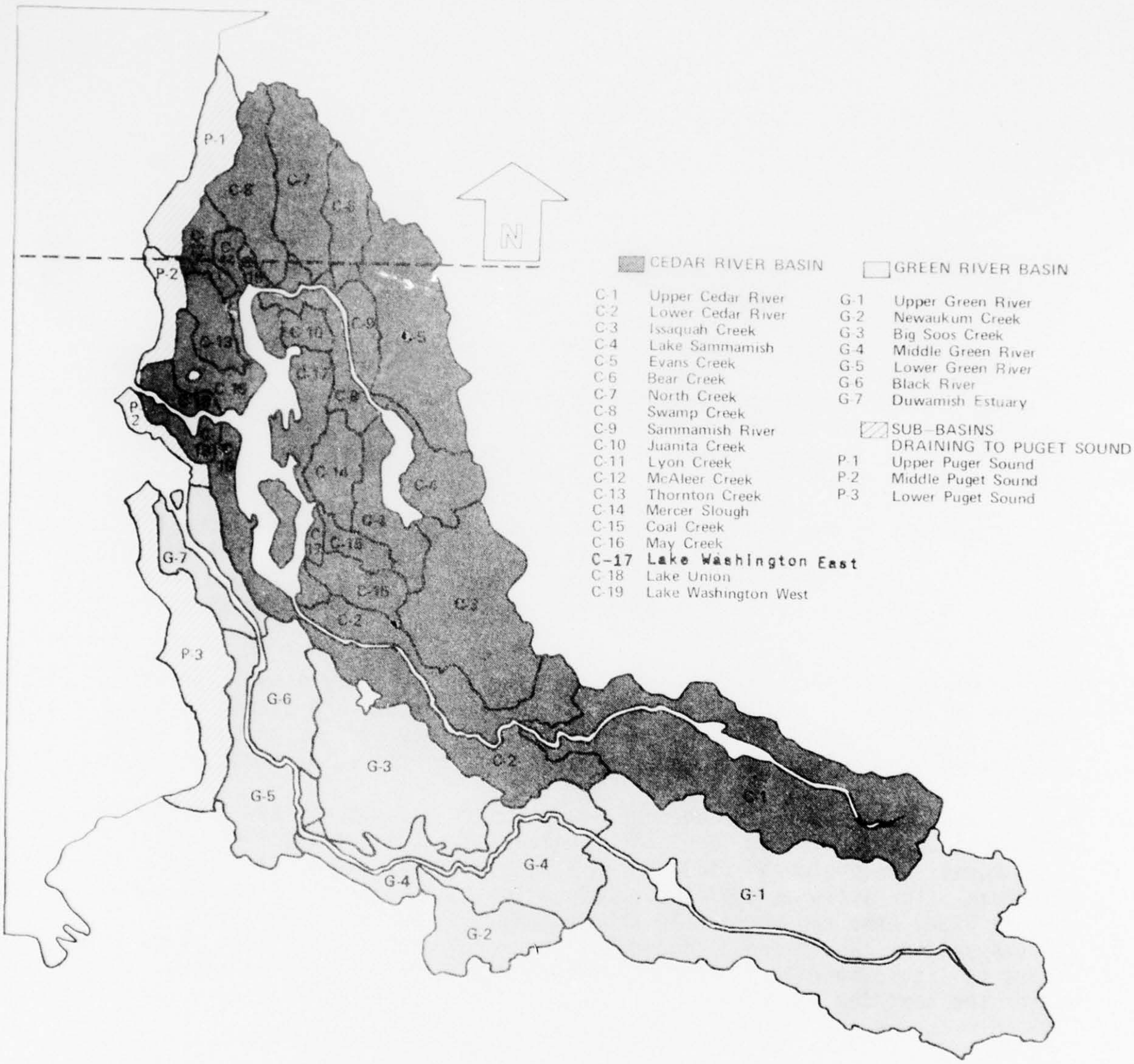


REGIONAL SUB-BASINS
FIGURE 2

conduit of sufficient size to accommodate any flow and is buried beneath the ground or possibly placed in a concrete channel. A stream also may be piped underground by an insensitive landowner or developer who wishes to increase the "usable" square footage of his property. The Study Area now has a significant amount of the once-natural streams in pipes and conduits. The distances that stream systems are piped varies: former streams in Seattle are now totally enclosed in pipe, but streams such as May Creek on the east side of Lake Washington have little or no pipe.

The drainage system serving the City of Seattle has a second unusual characteristic. The majority of the City has been served by combined sewers in which sanitary and storm sewage flow in the same pipe. However, the problems resulting from this method are now being corrected by a relatively costly separation program that will place almost all storm drainage systems underground.

As a basis for comparison of natural and man-made systems, the following table shows the existing lengths of natural streams, storm drainage pipes of 30 inches in diameter or larger, and combined sanitary and storm sewer systems 30 inches or larger for each regional sub-basin and demonstration area.

Of the 977 miles of streams identified in the Study Area*, approximately 147 miles or 15% are now in pipes and conduits. The extent of these installations is related to the amount of impervious surface present in the Study Area which presently is approximately 17% of the total area.

The Water Quality Management Study Report has categorized the streams according to the existing level of urbanization. These categories are: (I), Rural - Undeveloped; (II), Rural - Agricultural; and (III), Urban - Suburban. The assignment of these categories to the various named streams in the Study Area can be seen in the regional sub-basin descriptions in this Appendix. While these categories accurately reflect existing conditions, there is little hope that they will remain valid for many of the streams after the next few years.

* Excludes the Upper Green River and Upper Cedar River Sub-Basins and the main stems of the Green and Cedar Rivers.

TABLE 1

EXISTING SYSTEM INVENTORY

REGIONAL SUB-BASINS
(excluding demonstration areas)

		Natural Stream*	Pipe/Conduit**	Combined System**
C-2	Lower Cedar River	55.2 miles	-	-
C-3	Issaquah Creek	63.6	0.1 miles	-
C-4	Lake Sammamish	27.0	3.2	-
C-5	Evans Creek	75.0	0.2	-
C-6	Bear Creek	26.2	0.1	-
C-7	North Creek	21.8	0.1	-
C-8	Swamp Creek	30.2	1.2	-
C-9	Sammamish River	38.9	1.9	-
C-10	Juanita Creek	15.4	0.7	-
C-11	Lyon Creek	9.3	1.0	-
C-12	McAleer Creek	10.2	2.0	-
C-13	Thornton Creek	8.4	2.0	-
C-14	Mercer Slough	26.3	4.6	-
C-15	Coal Creek	14.9	0.5	-
C-16	May Creek	22.2	-	-
C-17	Lake Washington East	19.7	8.1	-
C-18	Lake Union	-	-	30.0 miles
C-19	Lake Wasnington West	8.4	3.8	21.4
G-2	Newaukum Creek	32.8	1.1	-
G-3	Big Soos Creek	65.8	-	-
G-4	Middle Green River	70.4	-	-
G-5	Lower Green River	38.1	8.8	-
G-6	Black River	33.5	4.5	-
G-7	Duwamish Estuary	10.3	11.6	12.0
P-1	Upper Puget Sound	20.3	5.2	-
P-2	Middle Puget Sound	9.7	0.4	3.0
P-3	Lower Puget Sound	19.5	2.0	6.0
	SUB-TOTALS	773.1	63.1	72.4
	DEMONSTRATION AREAS			
	Thornton Creek	11.5	4.1	-
	Kelsey Creek	15.0	1.8	-
	May Creek	- See C-16 May Creek above -		
	Mill Creek	20.1	2.8	-
	Miller Creek	9.6	3.1	-
	SUB-TOTALS	56.2	11.8	
	TOTALS	829.3 miles	74.9 miles	72.4 miles

* Excludes main stems of the Green and Cedar Rivers.
** Pipes and conduits 30 inches or larger.

PRESENT AND FUTURE URBAN DRAINAGE PROBLEMS

PRESENT PROBLEMS

During the inventory process, there also was an examination made of problems relating to drainage. There were found to be problems within existing drainage systems, such as conduits and natural systems, and also problems associated with some of the isolated lowlands or wetlands, typical of the Puget Sound geology. Problems of all types related to drainage were given consideration in the study. The same agencies which provided information on existing facilities also were asked to furnish their information on problems and damage losses resulting therefrom. In most instances, the inventory process of conditions and practices was conducted simultaneously with the examination of problems.

A complete record of all recorded and reported problems were compiled for each sub-basin. Table 2 indicates problem data sources by agency, citizen report, newspaper, or field observation for each sub-basin.

The public was asked to tell of their problems, and to give their opinions about how problems could be solved, at a series of community meetings conducted at nine locations throughout the Study Area during November, 1972. Problems were tabulated from the questionnaires completed by attending citizens. The total number of questionnaires returned and used in determining responses was 170.

Nearly all who attended the November, 1972, meetings lived in the Study Area, while two-thirds lived in an incorporated city or town. Nearly 90 percent of the citizens owned their homes. Most residents were aware of the problems involved with urban runoff during periods of heavy rainfall, while approximately 80 percent believed that these problems existed in their immediate neighborhoods. It was the consensus of 87 percent that temporary storage of stormwater runoff in their neighborhoods would be acceptable, with open fields, golf courses, roadside ditches, parking lots, and picnic areas the locations preferred, in the order listed. Very few believed that the water should be allowed to stand in the streets or their lawns and driveways, but about half were willing to permit temporary storage of stormwater elsewhere on their property.

Public opinion was overwhelmingly against the use of concrete linings in streams in order to lessen damage by stormwater runoff, while the use of a rock or boulder lining was more environmentally acceptable.

Attendees overwhelmingly favored the use of tax money to pay the cost of stormwater runoff control and believed that the cost should be shared by residents of both hillsides and low-lying areas.

Most of the attendees believed that existing control measures are insufficient to protect natural stormwater runoff channels and that zoning should be adopted for the purpose, although development of presently vacant land should not be completely halted, and streams, swampy areas, and other natural areas where development was limited should be opened for public recreational use.

TABLE 2
EXISTING PROBLEM DATA SOURCES

Sub-Basin		Municipal Files	County Files	State or Federal Report	Small Business Admin.	Damage Survey Report	Engineering Report	Citizen Report	Newspaper	Photograph	Field Observation
Upper Puget Sound	P-1	X	X				X		X		X
Middle Puget Sound	P-2	X	X		X		X		X	X	X
Lower Puget Sound	P-3	X	X		X		X	X	X	X	X
Newaukum Creek	G-2	X								X	X
Big Soos Creek	G-3	X	X			X			X	X	X
Middle Green River	G-4	X			X	X		X			X
Lower Green River	G-5	X	X	X	X	X	X	X	X	X	X
Black River	G-6	X	X	X	X	X	X	X	X	X	X
Duwamish Estuary	G-7	X		X				X	X	X	X
Lower Cedar River	C-2	X		X	X			X	X	X	X
Issaquah Creek	C-3	X		X	X	X	X	X	X	X	X
Lake Sammamish	C-4	X	X		X	X		X	X		X
Evans Creek	C-5		X	X	X		X		X		X
Bear Creek	C-6		X								X
North Creek	C-7		X				X				X
Swamp Creek	C-8	X	X		X		X	X		X	X
Sammamish River	C-9	X	X	X	X	X	X				X
Juanita Creek	C-10		X							X	X
Lyon Creek	C-11		X							X	X
Mc Aleer Creek	C-12		X					X		X	X
Thornton Creek	C-13	X						X		X	X
Mercer Slough	C-14	X	X		X		X	X	X	X	X
Coal Creek	C-15				X				X	X	X
May Creek	C-16		X				X	X		X	X
Lake Washington East	C-17	X	X		X	X	X	X			X
Lake Union	C-18	X			X	X					
Lake Washington West	C-19	X			X	X					X

They believed that building should be restricted in low-lying areas subject to seasonal flooding, but that changes to more intense use of urban or suburban lands would not be completely stopped, but rather controlled in some way. Citizens' opinions were mixed with regard to the level of government which should be responsible for control measures, but spoke most affirmatively of regional organizations, such as Metro.

Streams were considered to be important urban assets, while swamps and seasonal swampy areas were also believed to be valuable assets to the environment. Most attendees considered that building should be restricted within 100 feet of natural water runoff features, except lakes and major rivers, while streams, swamps, and seasonally swampy areas should be used for both active and passive recreation.

From the inventory process, the above described questionnaire results, and from additional problem input obtained from the public at the January, 1973, series of community meetings, maps were prepared that indicate problem location and type. These maps were used at the June, 1973, round of community meetings to show citizens the wide range of drainage problems in the Study Area.

A summary of reported problem types is listed by sub-basin in Table 3. Additional problems found during the hydraulic analysis of the existing drainage systems are included in the table.

The only water-quality problems reported by citizens were those of turbidity, and they are grouped in the table with sedimentation problems.

The most frequently reported problem was ponding or standing water, which accounted for 25% of the total problems reported. Second most frequently reported was slides, 24% of the total. The problem of slides is over representative of type and frequency due to a large amount of data received from one source, the Small Business Administration.

The ranking of documented problem types by reported events is:

Ponding	93
Slides	91
Stream Flooding	37
Ditch Flooding	35
Structural Failure	37
Sedimentation	27
Erosion	43
Home Flooding	21
Debris	10
Gutter Overflow	4
TOTAL EVENTS	398

TABLE 3
SUMMARY OF DRAINAGE PROBLEMS BY TYPE

Sub-Basin		Number of Problems Reported	Ponding	Earth Slide	Stream Flooding	Ditch Flooding	Structural Failure	Sedimentation and/or Turbidity	Erosion	Home Flooding	Debris	Gutter Overflow	Reported Damages 1972-1973
Upper Puget Sound	P-1	10		X		X	X	X	X		X		None
Middle Puget Sound	P-2	8	X	X		X	X	X	X		X		$ 19,000
Lower Puget Sound	P-3	61	X	X	X	X	X	X	X	X	X	X	101,000
Newaukum Creek	G-2	2	X		X				X				None
Big Soos Creek	G-3	5		X	X				X		X		3,000
Middle Green River	G-4	4	X	X					X		X		13,000
Lower Green River	G-5	43	X	X	X	X	X	X	X	X	X	X	109,000
Black River	G-6	22	X		X	X	X	X	X	X			82,000
Duwamish Estuary	G-7	24	X	X	X	X		X	X	X	X		245,000
Lower Cedar River	C-2	9		X	X	X		X				X	57,000
Issaquah Creek	C-3	9	X	X		X		X	X	X	X		174,000
Lake Sammamish	C-4	7		X	X	X		X	X	X	X		26,000
Evans Creek	C-5	2	X	X	X	X	X		X				4,000
Bear Creek	C-6	2	X		X	X	X		X				None
North Creek	C-7	7	X		X	X			X		X		None
Swamp Creek	C-8	11	X		X			X	X		X		2,000
Sammamish River	C-9	16	X	X	X	X			X				18,000
Juanita Creek	C-10	2	X						X				None
Lyon Creek	C-11	5	X					X	X		X		None
Mc Aleer Creek	C-12	3	X		X			X	X	X			None
Thornton Creek	C-13	42	X	X	X	X	X	X	X	X	X	X	182,000
Mercer Slough	C-14	19	X	X	X	X	X		X		X		142,000
Coal Creek	C-15	2			X				X				1,300
May Creek	C-16	2	X		X			X	X				None
Lake Washington East	C-17	53	X	X		X		X	X				184,000
Lake Union	C-18	11		X		X			X	X			87,000
Lake Washington West	C-19	17	X	X		X			X	X			57,000
	TOTAL	398										TOTAL	$1,506,300

Of the reported problems, the occurrence by type of drainage system is as follows:

Open Channel (include natural streams, ditches, channels, etc.)	245
Combined Sewers	39
Storm Drains	64
Curb and Gutter Systems	6
Others	11
Overland Flow	1
TOTAL	366*

* This differs from the total problems reported because in some cases, more than one type of problem occurred at the same location.

The total number of problems is rather small by comparison to the Study Area, but are considered typical. Review of the reported problems seems to indicate that the major problems occur in open channel conveyance systems. Mostly problems occur in natural creeks or creeks that have been altered or impacted by urban runoff. Problems cited above are normally very short-lived, less than a few days.

Generalized findings are:

1) Existing storm sewers were found to be adequate except in those instances where the land use was not realistically projected at the time the storm sewers were designed.

2) Most storm sewers outfall directly to a natural channel, regardless of the channel's capacity or sensitivity to increased flows.

3) Many roadside ditches have 12-inch diameter culverts at driveways; flow capacity is not considered. Usually, the property owner or developer installs the smallest culvert as per local-agency regulations.

4) Many roadside ditches are at grades too steep to control erosion of native soil, thereby causing erosion and eventual sedimentation.

5) The number of reported problems by area are believed to be an indication of public concern and awareness, not the magnitude of problems.

The reported monetary damages obtained from local agencies are also listed in Table 3. These amounts represent damages from storm events that occurred during the years 1972 and 1973. During March, 1972, a storm with a recurrence interval of approximately 25 years occurred and caused roughly 90 percent of the reported damages for this two-year period.

The total reported damage amount of $1,506,300 probably encompasses only a small portion of the actual damages, as considerable damage was not

estimated or reported. This amount, therefore, should be considered a lower limit for any two-year period.

Within each of the demonstration areas, estimates were made of the annual damage from floods and drainage waters under existing land-use and drainage-system conditions. This information is presented in Table 4. Agricultural inundation damage was estimated to be $25 per acre per year for crop and pasture lands. All other damages were either from reported amounts, or from estimates based upon 1973 cost levels.

Because of a lack of data, it was not possible to define the extent of flood plain lands within each demonstration area. Therefore, for comparison purposes, damages per square mile of total watershed area are presented instead of the more conventional method of relating damages to only those lands within flood plains. The annual direct and indirect damages per square mile are indicated in Table 4, and totals ranged from a low of $1,200 for Kelsey Creek to $4,600 for Miller Creek. The average per square mile for all five demonstration areas was $2,700.

The demonstration areas represent a composite of the types of land-use and development conditions found throughout the Study Area. The average annual damages provide another rough estimate of total annual damages that are experienced with the existing developed and partially developed urban/suburban lands of the Urban Runoff and Basin Drainage Study Area.

Total Annual Damages: 730.5 sq. miles x $2,700/sq. mi. = $2,000,000

The figure of $2,000,000 per year is an estimate. The almost total lack of accurate data, and the enormous time and cost efforts of flood hazard appraisals make further refinement impractical at this time.

In addition to problems which have affected individual property owners, a whole series of problems plague the natural stream system.

Most notable among these are:

1. Loss of fisheries: This is due to a combination of urbanization-induced factors; siltation of spawning beds; intolerable increases in water temperature and decreases in dissolved oxygen content from vegetation removal; low flows which impede fish passage and reduce water quality (attributable to filling in of wetlands and paving over of natural ground surfaces); and construction and placement of culverts, fences, wiers, etc., which do not allow fish passage.

TABLE 4

ANNUAL DAMAGE FROM FLOODS AND DRAINAGE WATERS
(Existing Conditions)

		Thornton Creek (6.9 sq.mi.)	Kelsey Creek (9.4 sq.mi.)	May Creek (13.0 sq.mi.)	Mill Creek (13.0 sq.mi.)	Miller Creek (8.9 sq.mi.)
DIRECT DAMAGES						
Agricultural	Crop inundation			$ 2,720	$26,000	
	Damage to stored crops					
	Damage to livestock					
	Equipment and buildings					
	Sediment deposition					
	Bank erosion			350		
Urban/Suburban	Residential inundation	$ 9,250	$ 3,190	3,600	} 12,000	$ 7,300
	Commercial/industrial inundation					2,000
	Bank erosion		400		3,000	5,140
	Sediment deposition	1,000	4,350	8,800	1,500	0
	Damage prevention and clean-up by King County				1,500	20,000
Public, Semi-Public and Utilities	Roads and bridges			1,500	100	
	Railroads or airports					
	Parks		300			
	Schools or churches		1,400			
	Utilities (sewerage, electric, etc.)					
	Sub-Total	$10,250	$ 9,640	$16,970	$44,100	$34,440
INDIRECT DAMAGES						
Loss of business and/or services; Emergency services during floods; Re-routing road and railroad traffic; Impaired land use; Security and health	} 20% of direct damages	$ 2,050	$ 1,930	$ 3,400	$ 3,820	$ 6,890
Total Estimated Annual Damages ($138,490)		$12,300	$11,570	$20,370	$52,920	$41,330
Annual Damages per Square Mile (Ave. $2,700)		$ 1,800	$ 1,200	$ 1,600	$ 4,100	$ 4,600

* See footnote page VI

2. Loss of wetlands: As economic pressures build within urbanizing areas, wetlands, which were previously considered unbuildable because of excessive construction costs, are developed. The high construction costs are offset by potentials of economic gain which the wetlands offer as the last undeveloped properties within the urbanizing areas. When the wetlands are drained or filled, their water retention and purification function is destroyed. The watercourse must then endure highly variable silt and pollution-laden runoff volumes unaided.

3. Degradation of water quality: Water quality problems occur in two general areas: (1) As streamside vegetation is removed, an increase in water temperature and decrease in dissolved oxygen content is experienced. (2) Pollution loads carried by streams during and after storms can be of short-term duration but of long-term consequence. Parking lot and roadway runoff (high in hydrocarbon and heavy metal pollution), runoff from fertilized lawns, and silt laden runoff from unprotected construction sites, all enter the streams during storms. Depending upon the severity or frequency, the introduction of these pollutants can have a devastating effect on the aquatic biota and dependent terrestrial fauna.

4. Loss of stream aesthetics: It is difficult to assign a dollar cost to the aesthetic value and enjoyment provided by a natural stream, and yet, pleasant moments have been provided to those people who have experienced the beauty of a rushing stream or the peaceful solitude of an upland marsh. These natural benefits disappear when streams are placed in conduit or cease to flow because a wetland area has been drained and filled over for a new housing development. Unfortunately, this type of loss occurs continually on the streams within the Study Area.

FUTURE PROBLEMS

The drainage problems that exist today begin to establish the pattern and format for problems that can be expected in the future. Unless remedial measures are taken, future drainage problems will tend to build upon and intensify drainage problems that now exist. And, in all likelihood, new problem areas will be created which do not exist at this time.

In order to help identify the magnitude and probable location of future problems, the present drainage system has been analyzed with the aid of the computer models under runoff conditions from projected future land use. This has resulted in a definition of areas where the present system will be inadequate for future land-u e runoff conditions.

The general pattern which occurs begins with upstream development that does not have adequate runoff control. This leads to an overtaxing of downstream facilities which may be characterized by flooding, an accelerated erosion rate, sediment deposits on stream beds, and the formation of offshore

deltas. Many of these problems can then be transmitted further downstream in an attempt to correct them at the initial place of occurrence. Riprapping, dredging, diking, and channel realignment are typical of "corrective" measures which, in fact, transmit a problem further downstream.

One way to gain an easy understanding of what might happen to a stream system is to make a comparison between a sub-basin which has experienced considerable development (in excess of 15% impervious surface) and one which has experienced little development (5% impervious or less). The sub-basin which has little development usually will contain few man-made structures (culverts, retaining walls, etc.) within the stream and display few signs of erosion, siltation or past flooding. Conversely, the sub-basin which has a higher degree of development often will contain numerous control features including rip-rapped or concrete sided channels, stream sections completely enclosed in conduit, check dams, etc. and show definite signs of erosion and siltation. If the undeveloped sub-basin begins to develop without special runoff controls, the probability is quite high that it, too, will eventually require control devices and begin the gradual process of deterioration.

The following listing presents regional sub-basins and demonstration areas by the severity of drainage problems that are likely to occur by the year 2000 if corrective measures are not taken. Group One is for those basins currently experiencing severe drainage problems and in which an intensification of problems can be expected; Group Two for those that probably will experience severe damage by the year 2000; and Group Three for those expected to have less severe drainage problems by the year 2000.

GROUP ONE

Black River

Miller Creek Demonstration Area

Middle Puget Sound

Duwamish Estuary

Lower Green River*

Lake Washington East

Kelsey Creek Demonstration Area

Mercer Slough*

Thornton Creek Demonstration Area

Thornton Creek*

McAleer Creek

Lyon Creek

Juanita Creek

GROUP TWO

Lake Sammamish

North Creek

Mill Creek Demonstration Area

* See footnote page 15

Swamp Creek	Upper Puget Sound
Lake Washington West	Lower Puget Sound*

GROUP THREE

Lower Cedar River	Coal Creek
Issaquah Creek	May Creek Demonstration Area
Evans Creek	Newaukum Creek
Bear Creek	Big Soos Creek
Sammamish River	Middle Green River

*Regional sub-basins do not include the demonstration areas located therein.

The loss of additional fisheries resource and stream aesthetics can be expected if existing trends continue. Also, the educational value of the natural stream ecosystems will be lost or further removed from those who wish to make use of them. Economic costs to the community to accommodate runoff from projected future growth must be weighed against any potential economic gains the growth itself may bring. If citizens agree to spend a portion of available revenue, the use of the money (i.e. schools vs. police vs. roads vs. drainage, etc.) must be made judiciously because the correction of a problem in one area may lead to the worsening of a problem in another area.

The last major area for which future problems can be anticipated is with water quality. A gradual degradation of water quality can be expected running parallel to the pace of urbanization. Pronounced changes probably would not occur over the short-run, but can be expected to ultimately eliminate fish productivity and lower water quality in those sub-basins where significant growth is projected to occur.

ALTERNATIVE DRAINAGE PLANS

INTRODUCTION

The alternative drainage plans, described in this section, represent reasoned approaches for each of the regional sub-basins and demonstration areas. They report the existing and projected land-use and drainage situation and they reflect a consideration for what is possible, feasible and desirable in view of the general goal to obtain the greatest benefits to the community and its environment. The alternative plans are not intended to be final plans for the design of specific physical facilities, but they are based upon an accumulation and integration of facts that are necessary prerequisites for design and implementation, including community action.

Plan development processes from which the alternatives are derived are explained in more detail in the Technical Report.

LAND-USE PROJECTIONS

The alternative drainage plans have been developed to provide methods for accommodating runoff from land under use conditions projected for the year 2000. Each of the regional sub-basins and demonstration-area projections were based upon common methodology for population, economic and land-use allocation forecasting, and are consistent with forecasts used for other RIBCO studies. These land-use forecasts were provided by the Puget Sound Governmental Conference (PSGC) on the basis of census tracts through the use of an Activity Allocation Model (AAM) which distributes region-wide forecasts of population and economic activity to a number of small districts. The AAM output was not directly usable for the Urban Runoff and Basin Drainage Study because the reported districts were not based upon drainage sub-basins. Local Planning Agencies reworked the land-use projections provided by the AAM to conform with sub-basin boundaries.

The land-use projections for the year 2000 were prepared for two alternative growth concepts, designated as the Comprehensive Plan and the Corridor Plan. The PSGC defines these concepts as follows:

Comprehensive Plan

This concept assumes continuation of the past decade's growth trends and development policies, but with some accommodation for plans to reach land-use goals in an orderly manner. Major features include:

1. Acquisition of open space as demands rise and finances permit, but with acquisition concentrated in the urban area for specific purposes, rather than as dictated by natural factors that bear upon construction costs;

2. Location of new employment in new centers only when it cannot be accommodated by existing centers, and then with regard to plans for transportation (including high-speed mass transit) and residential development; and

3. Location of residential development relative to existing service centers instead of encouraging the establishment of new, automobile-dependent satellite communities that result from real estate speculation and promotion.

Corridor Plan

This concept assures that new development will be concentrated in corridors radiating outward from larger cities along major transportation lines. Open space separates the corridors. The concept calls for:

1. Conservation of land based upon suitability analysis of natural factors;

2. Location of new employment activities along transportation development routes (including a high-speed mass transit system); and

3. Development of residential units within existing residential areas with high-density around transit terminals and central business districts.

Land use was designated in the following categories:

- Single Family Residential
- Multi-Family and Other Residential
- Commercial Services
- Government/Education/Institutions
- Industrial
- Parks and Dedicated Open Spaces
- Agriculture
- Special: Airports, Railyards, Freeways, Highways
- Unused Land
- Water

Existing and future land-use plans are shown in the Technical Report on Figures 9 through 11.

Analysis of runoff characteristics from either development concept produced little or no substantive change in the required drainage system except in a few isolated instances.

Storms that have 10-year recurrence intervals have been used to determine the type of problems that would be encountered by the existing drainage systems of each regional sub-basin under future land-use projections.

FORMULATION

The procedure for developing alternative drainage plans began with a field inspection of each regional sub-basin, and particularly the drainage systems.

Obstructions to flow in channels were located, as were flooded areas and other drainage problems. With the field information, the reported drainage problems, and citizen preferences in mind, drainage-system modifications were formulated and several alternative approaches were developed. Considering agency and citizen review comments, two alternatives were selected for further study.

Once the two alternative plans were scoped, potential modifications to the existing drainage system were listed. These modifications were then entered as input to the computer models and simulation runs were made. The results of this first simulation identified those elements of the system that were not correctly sized to accommodate the runoff expected under the year 2000 land use.

In the case of the alternative tending toward a non-structural approach, additional runoff controls or flood-plain zoning modifications were identified. In the alternative more closely related to a structural approach, it was often found that increasing the capacity of the conveyance system in the upstream portion of the sub-basin created a new flooding problem in the downstream reaches of the drainage system.

With an evaluation of the results of the first simulation, additional runoff controls, holding ponds, enlarged conveyance facilities, and other adjustments were proposed and a second computer simulation run was made. If the results of this second simulation indicated that all problems from the previous simulation were eliminated, no further computer runs were made. However, if problems did remain the process was repeated until they were solved.

Combinations of various elements from each of the three general drainage concepts were utilized in every sub-basin and demonstration area. Flood-plain zoning was appropriate at the farthest downstream reaches of several streams due to the physical features of the sub-basin. These flood-plain zones can be in the form of a flood plain available to the stream as in nature, or an artificial flood plain adjacent to the natural stream so that the area is available to the public for use at times when the artificial flood plain is not needed to accommodate peak rates of flow.

Runoff controls were considered in those sub-basins where a substantial portion of the land is projected to change from undeveloped to developed by the year 2000. For those sub-basins where little urban growth can take place due to the present high level of urban development, runoff controls were considered inappropriate.

Holding pond sites are available in almost all of the sub-basins, and the use of holding ponds proved to be beneficial in simulation throughout the Study Area. Wetlands and bogs also can be utilized in most of the sub-basins as runoff storage areas.

Bypass pipelines parallel to natural channels have application in areas

where the natural stream can no longer accommodate large flows. These pipelines, or diversions, will take only peak rates of flow, leaving low and natural flows in the stream.

Each alternative drainage plan developed by the URBD Study utilizes a combination of drainage concepts. However, one alternative was developed to rely more heavily upon constructed facilities, whereas the other placed a greater emphasis upon runoff control and the preservation of the natural drainage system.

The alternative plans were developed to provide methods for accommodating without flooding the storm runoff resulting from a rainfall with a 10-year recurrence interval.

In many sub-basins, existing flow restrictions, such as undersized and blocked culverts and channels, presently cause flooding and results in moderated peak flows. When these restrictions are removed as part of an alternative plan, the flooding is alleviated but the peak flow rates are increased due to the entry of additional waters to be conveyed by the improved drainage system. This increase peak-flow condition occurs in at least one alternative plan for almost all sub-basins.

For each alternative plan, the water quality concentrations at peak flows are presented for five constituents on the basis of runoff resulting from a 10-year storm. These concentrations were simulated by the computer models and represent conditions that would exist when a 10-year storm was preceded by five days with little or no rainfall.

EVALUATION

Each alternative drainage plan was field checked by a two-man assessment team to determine if the proposed plan was environmentally and socially sound. An evaluation matrix containing 34 separate elements, which were grouped into the following five general categories, was used by the assessment team and was filled out in the field:

1. Effectiveness - considers system's (alternative plan) ability to handle runoff.

2. Human Values - considers human uses and impacts of the systems.

3. Environmental Factors - considers system's natural environmental benefits and impacts.

4. Implementation - considers program mechanisms to accomplish the alternative.

5. Resource Requirements - considers expended or committed resources necessary to physically realize the alternative.

Relative weights from one to four were assigned to each element indicated on the evaluation matrix, because each element did not represent equal benefits or impacts.

The evaluation of each element, as it applies to the various drainage alternative plans, was done on the basis of a positive, negative, or neutral rating. Positive (+1) indicates that the alternative has a beneficial (least negative) impact on the element being rated. Negative (-1) indicates that the alternative has a non-beneficial (most negative) impact upon the element. Neutral (0) indicates that the alternative does not significantly affect the element. The sum of the 34 weighted elements when all receive a positive rating is plus 108, and when the elements all receive a negative rating,the sum is a minus 108.

The total score assigned to each alternative should be considered a guideline only and must be tailored by local decision makers and their staffs to reflect subsequent changes in data, conditions and values. Table 5 contains the ratings for each of the alternative drainage plans developed for the 27 regional sub-basins and five demonstration areas.

These evaluation ratings to be meaningful must be related to the descriptions and alternative drainage plans for each regional sub-basin. Although these ratings provide a general guide to the overall acceptability of an alternative, the real value of the evaluation process has been the opportunity it provided for continuous evaluation during the planning process itself.

Existing Conditions

An existing-conditions rating has been shown for each sub-basin in an attempt to give an overview of the relative condition of the natural drainage systems. This rating, while using the same range of values as the alternative matrix, is not based upon the numerous factors used for alternative plan evaluation and therefore should only be considered a generalized rating when compared to ratings for alternative plans. The rating is entirely subjective but was accomplished after field checking each drainage system.

High scores were assigned to streams such as Newaukum and Big Soos because of the relative absence of man-made drainage facilities or encroachments. Ratings in the neutral range (-27 to +27) indicate strong influence upon the stream system by man-made drainage facilities or development. Streams in this range are in a critical condition and require immediate attention if they are to continue as positive elements of the drainage system, while at the same time remaining environmentally stable. Thornton Creek, Lyon Creek, Mill Creek, and Kelsey Creek all fall into this range. Ratings below -27 indicate that little of the natural stream system remains or that extensive modification has been made. McAleer Creek and the Black River represent streams in this latter category.

Year 2000 Alternative Drainage Plans

The evaluation ratings applied to the alternative drainage plans indicate how the stream would be influenced by the various features of the plan. A stream which already has experienced impacts from urbanization presents a more difficult problem to solve with regard to the development of drainage plans, and is often reflected in a lower score for the alternatives considered. Conversely, a stream such as Newaukum Creek is still far enough ahead of the impacts of urbanization that solutions to control runoff cover a wide range of choices amongst which usually exists environmentally sensitive alternatives. The resultant alternative ratings are therefore generally higher than the alternatives in sub-basins where urbanization has already occurred, but lower than existing conditions due to the fact that substantial urbanization is projected for the next 25 years.

Evaluations were not made for the condition of no additional drainage improvements with continued urbanization. However, with that condition, the evaluation ratings for the year 2000 land use would be much lower than the ratings of the alternatives presented in Table 5.

The range of values in the rating for a given alternative plan reflects the severity or sensitivity of the solution needed to control runoff. As an example, where the plan suggests the channelization (channel is regraded and realined with new side slopes, and possibly a change in depth and width) of a stream, it must be assumed that at least for the short term, and possibly for the long term, much natural stream-side vegetation would be eliminated, aquatic habitats would be damaged, wildlife habitats would be reduced, water quality would be impacted, and stream aesthetics would be irreversibly lost. Additionally, cost of channelization is relatively high when compared to other less structural controls such as ground water recharge and flood-plain zoning.

Channelization may allow greater land utilization by providing a more convenient stream alignment and a greater channel capacity to prevent overtopping, but this comes at the expense of an open greenway and the loss of a natural outdoor laboratory. Channelization to meet ever-increasing runoff from new impervious surfaces accomplishes little in promoting ground water recharge and may result in unacceptable low-flow conditions.

An example of how a higher rating could be obtained would best be represented by an alternative plan utilizing runoff control. Runoff control envisions either storage (detention) or recharge (where soil types permit) of peak flows to allow the natural stream system to continue functioning without incurring erosion and overtopping. Utilizing runoff control, stream-side vegetation, aquatic habitats, and wildlife habitats can continue to exist undisturbed. Water quality is enhanced through filtering or settling of sediments and general stream aesthetics remain unspoiled. Even as new impervious surfaces are developed, stream flows can remain fairly constant. Low flows are enhanced by water which has been introduced into the ground or released from detention sites. The cost of runoff control is usually less than the cost for those solutions involving extensive structural work,

TABLE 5

EVALUATION RATINGS

Regional Sub-Basins (excludes Demonstration Areas)

Regional Sub-Basin	Existing Conditions	Year 2000 Conditions Alt. I	Alt. II	Alt. III	Alt. IV
C-2 Lower Cedar River	+28 to + 54	- 9	+28	+18	
C-3 Issaquah Creek	+28 to + 54	+14	+14		
C-4 Lake Sammamish	0 to + 27	-25	+28		
C-5 Evans Creek	+83 to +108	+41	+53		
C-6 Bear Creek	+55 to + 82	+10 a. +19 b.	+23 a. +32 b.		
C-7 North Creek	0 to + 27	-40	+ 6		
C-8 Swamp Creek	0 to + 27	-34 a. -34 b.	+ 3 a. + 3 b.		
C-9 Sammamish River	+55 to + 82	+39	+64		
C-10 Juanita Creek	0 to + 27	- 2	+50		
C-11 Lyon Creek	-27 to 0	-36	+ 8	+11	
C-12 McAleer Creek	-54 to - 28	-47 a. -47 b.	+14 a. +14 b.		
C-13 Thornton Creek	-27 to 0	-26	- 4	+24	
C-14 Mercer Slough	-27 to 0	-35	+54		
C-15 Coal Creek	+55 to + 82	+16	+63		
C-16 May Creek	+55 to + 82	-14	+32		
C-17 Lake Washington East	-54 to - 28	-15	+12		
C-18 Lake Union	-	-	-		
C-19 Lake Washington West	0 to + 27	-15	+ 4		
G-2 Newaukum Creek	+83 to +108	-26	+73		
G-3 Big Soos Creek	+83 to +108	+ 6	+74		
G-4 Middle Green River	+83 to +108	+24	+75		
G-5 Lower Green River	-82 to - 55	-49	-37		
G-6 Black River	-82 to - 55	-51	-28		
G-7 Duwamish Estuary	-54 to - 28	- 4 a. - 4 b.	0 a. -		
P-1 Upper Puget Sound	0 to + 27	-22	- 2		
P-2 Middle Puget Sound	-27 to 0	-21	+ 8		
P-3 Lower Puget Sound	0 to + 27	- 2	+ 4		
Located Within		**Demonstration Areas**			
C-13 Thornton Creek Demo	-27 to 0	-31	-35	+16	+21
C-14 Kelsey Creek Demo	-27 to 0	-32	+67		
G-5 Mill Creek Demo	0 to + 27	-47	+ 9	-30	
P-3 Miller Creek Demo	-27 to 0	-12	-14	+ 8	

--- May Creek Demo (See C-16 above as Demonstration Area encompasses entire regional sub-basin)

a. Comprehensive Land Use Plan
b. Corridor Land Use Plan

such as channelization or conduits.

Other factors which influence the rating of an alternative are less dependent upon the type of solution being considered and more dependent upon the jurisdictional, economic, and legal framework within which the stream system exists and therefore tend to be more equal for various alternatives considered.

The five demonstration areas, Thornton Creek, Kelsey Creek, May Creek, Mill Creek and Miller Creek, each represent different natural conditions, different levels of human encroachment and obviously different problem/solution relationships. The process for evaluation was the same as that used for the other sub-basins although the detail of the alternative plans was greater and the solutions somewhat more intricate.

The preferred alternative for each of the demonstration areas registered a positive rating while only May Creek and Mill Creek had been considered as having a positive natural existing condition. This indicates that solutions to drainage problems, in these areas, can have a positive effect. The greater detail of study in the demonstration areas resulted in a somewhat more tailored solution and may have been reflected in higher scores for the preferred alternatives.

COSTS

Capital Costs

The estimated capital expenditures needed to accomplish the alternative plans for the various regional sub-basins are shown in Table 6. These costs are based upon actual construction costs in the Seattle area for June, 1973, and represent an Engineering New Record construction cost index of 1760. The costs included 50 percent for contractor profit, engineering, legal and contingencies. In addition, land costs, at 1973 prices, are included plus 50 percent for severance and acquisition. A detailed listing of unit prices is presented in Appendix B.

The total of the highest cost alternatives for each of the regional sub-basins is $102,100,000 based upon the Comprehensive land-use plan. The total drops to $98,400,000 for the Corridor land-use plan. Totals for the lowest-cost alternative for the comprehensive and corridor land-use plans were $67,500,000 and $66,800,000, respectively. Unit cost per square mile based upon 686.4 sq. miles, requiring separate drainage improvements, for highest and lowest cost plans amount to $149,000 and $97,000, respectively.

For the demonstration areas, the unit costs range from $123,000 to $46,000 per square mile for May Creek to $775,000 to $528,000 per square mile for Miller Creek. These values reflect the impact of urbanization upon storm drainage costs as May Creek is relatively undeveloped and Miller Creek is nearing complete development.

In all cases, the estimated capital costs are for trunk drainage systems only (accommodating 20-30 cfs). Depending upon the configuration and use of the land surface, the smallest element of a trunk drainage system would serve a watershed of roughly 30 to 100 acres.

The costs for building and house drains, storm water inlets, collector pipes, ditches, and laterals would vary from approximately $300 per acre for low density residential to $5,000 per acre for conventional storm sewer pipe systems in commercial areas, and would be in addition to the cost of the trunk drainage system.

Operation and Maintenance Costs

All of the drainage systems set forth in the alternative plans must be operated and maintained. The operation and maintenance for each system within the regional sub-basin and demonstration areas is estimated to cost annually one percent (1%) of the capital cost of the alternative drainage plan. Included in the cost are all personnel, equipment, supplies, and administration and general expenses necessary to operate and maintain channels and pipes, such as the removal of debris and sediment, unclogging of culverts, and vegetation and erosion control.

This one percent annual cost would be in addition to the annual costs

ESTIMATED CAPITAL COSTS OF ALTERNATIVE DRAINAGE PLANS

TABLE 6

REGIONAL SUB-BASINS a.

	Regional Sub-Basin	Drainage Area (Sq. Miles) b.	Alternative I	Alternative II	Alternative III	Alternative IV
C-2	Lower Cedar River	72	$ 800,000	$ 1,100,000	$ 1,800,000	
C-3	Issaquah Creek	58	500,000	500,000		
C-4	Lake Sammamish	35	2,200,000	1,700,000		
C-5	Evans Creek	49	1,700,000	900,000		
C-6	Bear Creek	17	2,000,000 c.	1,600,000 c.		
			1,100,000 d.	700,000 d.		
C-7	North Creek	29	9,100,000	2,900,000		
C-8	Swamp Creek	24	10,600,000 c.	5,200,000 c.		
			8,200,000 d.	5,200,000 d.		
C-9	Sammamish River	26	900,000	700,000		
C-10	Juanita Creek	7	1,900,000	1,800,000		
C-11	Lyon Creek	3.8	400,000	600,000	400,000	
C-12	McAleer Creek	8	3,200,000 c.	1,700,000 c.		
			3,200,000 d.	1,700,000 d.		
C-13	Thornton Creek	5.1	1,700,000	3,700,000	1,400,000	
C-14	Mercer Slough	7.4	5,600,000	700,000		
C-15	Coal Creek	7.2	2,100,000	700,000		
C-16	May Creek				(See Demonstration Area Below)	
C-17	Lake Washington East	32	2,700,000	1,600,000		
C-18	Lake Union	14 e.	No Alternatives Developed.			
C-19	Lake Washington West	28 f.	1,100,000	1,700,000		
G-2	Newaukum Creek	27	400,000	300,000		
G-3	Big Soos Creek	72	900,000	200,000		
G-4	Middle Green River	67	100,000	100,000		
G-5	Lower Green River	23	10,800,000	9,300,000		
G-6	Black River	27	19,100,000	17,700,000		
G-7	Duwamish Estuary	25 g.	2,300,000 c.	2,900,000 c.		
			2,500,000 d.	———		
P-1	Upper Puget Sound	22	6,500,000	4,000,000		
P-2	Middle Puget Sound	16 h.	2,400,000	1,300,000		
P-3	Lower Puget Sound	29 i.	8,700,000	8,600,000		
	TOTAL	730.5	Total of the Highest Cost Alternatives		Comprehensive	102,100,000
					Corridor	98,400,000
			Total of the Lowest Cost Alternatives		Comprehensive	67,500,000
					Corridor	66,800,000

DEMONSTRATION AREAS

Located Within						
C-13	Thornton Creek	6.9	2,900,000	4,500,000	2,500,000	3,500,000
C-14	Kelsey Creek	9.4	4,000,000	900,000		
C-16	May Creek	13	1,600,000	600,000		
C-5	Mill Creek	13	6,400,000	6,700,000	5,800,000	
P-3	Miller Creek	8.9	4,700,000	6,300,000	6,900,000	
	TOTAL	51.2				

FOOTNOTES

a. Regional sub-basin costs and areas (square miles) do not include the costs and areas of the demonstration areas located therein.
b. Excludes water surface areas of Lake Washington, Lake Sammamish, Lake Union, and Green Lake.
c. Year 2000 Comprehensive land use plan.
d. Year 2000 Corridor land use plan.
e. Entire area served by combined sanitary-storm sewer system.
f. Includes 19 square miles served by combined sanitary-storm sewer system.
g. Includes 0.2 square miles served by combined sanitary-storm sewer system.
h. Includes 5.5 square miles served by combined sanitary-storm sewer system.
i. Includes 5.4 square miles served by combined sanitary-storm sewer system.

now being expended by local agencies for operation and maintenance of their respective drainage systems as they now exist. The present and past operation and maintenance costs are not well documented, but are reported to be very small.

Alternative drainage plans utilizing ground water recharge facilities and holding ponds may have a slightly higher operation and maintenance cost than alternative plans comprised primarily of land-use restrictions, natural lakes, and closed pipe systems. However, because of the lack of site details and the preliminary nature of the alternative plans presented herein, operation and maintenance costs have been considered to be a uniform percentage of the respective alternative plan capital costs.

In addition to the operation and maintenance cost described above, there are two regional sub-basins and one demonstration area that have pumping plants in connection with the alternative drainage plans. Gravity flow alternatives were not possible in any of these three areas because of the high water level in the Green River. The estimated annual operation, maintenance (including overhaul, repair and part replacement), and power costs for these three are as follows:

	Alternative Plan I	Alternative Plan II	Alternative Plan III
Lower Green River Regional Sub-Basin (excludes Mill Creek Demo Area costs)	$ 70,000	$ 60,000	None
Black River Regional Sub-Basin (includes existing P-1 Pumping Plant)	$140,000	$140,000	None
Mill Creek Demonstration Area	$ 90,000	$ 70,000	$90,000

The above pumping-plant amounts were added to the previously described one percent costs to arrive at the total annual operation and maintenance cost shown in Table 7.

These estimated costs are for trunk drainage systems only, and do not include costs for the operation and maintenance of collector pipes and ditches, and laterals. These operation and maintenance costs do not include the cost of drainage management, short and long-range planning, runoff quantity and quality monitoring, accounting and billing, and other associated tasks required if a public utility drainage management organization was established. The formulation of, and the estimation of costs for, a comprehensive drainage utility organization are complex and beyond the scope of this study.

ESTIMATED OPERATION AND MAINTENANCE COSTS OF ALTERNATIVE DRAINAGE PLANS

TABLE 7

REGIONAL SUB-BASINS a.

	Regional Sub-Basin	Drainage Area (Sq. Miles) b.	Alternative I	Alternative II	Alternative III	Alternative IV
C-2	Lower Cedar River	72	$ 8,000	$ 11,000	$ 18,000	
C-3	Issaquah Creek	58	5,000	5,000		
C-4	Lake Sammamish	35	22,000	17,000		
C-5	Evans Creek	49	17,000	9,000		
C-6	Bear Creek	17	20,000 c. 11,000 d.	16,000 c. 7,000 d.		
C-7	North Creek	29	91,000	29,000		
C-8	Swamp Creek	24	106,000 c. 82,000 d.	52,000 c. 52,000 d.		
C-9	Sammamish River	26	9,000	7,000		
C-10	Juanita Creek	7	19,000	18,000		
C-11	Lyon Creek	3.8	4,000	6,000	4,000	
C-12	McAleer Creek	8	32,000 c. 32,000 d.	17,000 c. 17,000 d.		
C-13	Thornton Creek	5.1	17,000	37,000	14,000	
C-14	Mercer Slough	7.4	56,000	7,000		
C-15	Coal Creek	7.2	21,000	7,000		
C-16	May Creek				(See Demonstration Area Below)	
C-17	Lake Washington East	32	27,000	16,000		
C-18	Lake Union	14 e.	No Alternatives Developed.			
C-19	Lake Washington West	28 f.	11,000	17,000		
G-2	Newaukum Creek	27	4,000	3,000		
G-3	Big Soos Creek	72	9,000	2,000		
G-4	Middle Green River	67	1,000	1,000		
G-5	Lower Green River	23	178,000	153,000		
G-6	Black River	27	331,000	317,000		
G-7	Duwamish Estuary	25 g.	23,000 25,000	29,000 ——		
P-1	Upper Puget Sound	22	65,000	40,000		
P-2	Middle Puget Sound	16 h.	24,000	13,000		
P-3	Lower Puget Sound	29 i.	87,000	86,000		
	TOTAL	730.5	Total of the Highest Cost Alternatives		Comprehensive Corridor	1,231,000 1,194,000
			Total of the Lowest Cost Alternatives		Comprehensive Corridor	875,000 868,000

DEMONSTRATION AREAS

Located Within						
C-13	Thornton Creek	6.9	29,000	45,000	25,000	35,000
C-14	Kelsey Creek	9.4	40,000	9,000		
C-16	May Creek	13	16,000	6,000		
C-5	Mill Creek	13	154,000	137,000	148,000	
P-3	Miller Creek	8.9	47,000	63,000	69,000	
	TOTAL	51.2				

FOOTNOTES

a. Regional sub-basin costs and areas (square miles) do not include in the costs and areas of the demonstration areas located therein.
b. Excludes water surface areas of Lake Washington, Lake Sammamish, Lake Union, and Green Lake.
c. Year 2000 Comprehensive land use plan.
d. Year 2000 Corridor land use plan.
e. Entire area served by combined sanitary-storm sewer system.
f. Includes 19 square miles served by combined sanitary-storm sewer system.
g. Includes 0.2 square miles served by combined sanitary-storm sewer system.
h. Includes 5.5 square miles served by combined sanitary-storm sewer system.
i. Includes 5.4 square miles served by combined sanitary-storm sewer system.
j. All costs in this table are in addition to the annual costs now being expended by local agencies for operation and maintenance of the drainage systems as they now exist.

QUALIFICATIONS

The alternative plans presented in this appendix represent a continuation of the efforts of King and Snohomish Counties and local agencies to develop drainage plans which respond to projected land use and future runoff characteristics on a watershed by watershed basis. The land-use allocation procedure which formed the basis for runoff projections is at best, preliminary. The first concern is that land use has never been aggregated or projected on the basis of watershed boundaries. This results in a questionable basis for comparison with future land use. Secondly, the Activity Allocation Model distributed future population and economic activity (and resultant land use) on the premise of growth trend continuation. This premise is highly questionable and subject recently to close scrutiny by many elected public officials, organizations and the general public. While this study did not attempt to reallocate land use based upon the runoff problems it forecast, the value and need for such a study is apparent.

Another area where the alternative plans need refinement is in the definition of the existing drainage systems. Many man-made improvements are a matter of public record. Unfortunately, many more are not, thus making the task of mathematically describing the system for computer analysis that much more uncertain. The record of natural stream, floodway and wetland conditions is almost unwritten.

Closely associated with this problem is the lack of stream-flow gages, water-quality monitoring stations and rainfall gages, all of which are needed to gain an accurate idea of actual and probable future runoff problems within the various watersheds.

The alternative plans do establish the order of magnitude of the runoff problem under projected land use conditions and can serve as the basis for developing more specific drainage plans in the future. They have helped to identify the sub-basins of high priority drainage needs and have established the runoff control and water-quality improvement functions of wetlands and natural storage sites.

The process that has started must be improved upon and continued if the region is to seriously pursue the preservation of its many streams and wetlands.

The results of the water quality model simulation for each of the subbasins are useful to compare between basins. Before extrapolating to other uses, however, the limitation should be reviewed as described in Appendix B, Urban Storm Drainage Simulation Models, and Appendix C, Storm Water Monitoring Program.

REGIONAL SUB-BASINS

This section contains descriptions and possible alternative drainage plans for each of the following nine regional sub-basins. These sub-basins, plus the Upper Green River Sub-Basin*, provide the drainage network for the entire Green River Basin and those sub-basins draining to Puget Sound (bound following page 31).

GREEN RIVER

- G-2 Newaukum Creek
- G-3 Big Soos Creek
- G-4 Middle Green River
- G-5 Lower Green River
- G-6 Black River
- G-7 Duwamish Estuary

PUGET SOUND

- P-1 Upper Puget Sound
- P-2 Middle Puget Sound
- P-3 Lower Puget Sound

Descriptions and alternative drainage plans for the regional sub-basins within the Cedar River Basin are presented in Volume 1.

DEMONSTRATION AREAS

In addition to the development of alternative drainage plans for each of the 27 regional sub-basins, five areas were selected by RIBCO for more detailed analysis, greater local citizen involvement, and additional use of drainage simulation models. In all, a total of 39 separate areas were proposed by local, state and federal agencies, consulting firms, and individuals for special consideration. From these 39 proposals, the following five demonstration areas were chosen:

1. Thornton Creek (North Fork) - part of Thornton Creek Sub-Basin
2. Kelsey Creek - part of Mercer Slough Sub-Basin
3. May Creek - the entire regional sub-basin

*Because of extensive public ownership, this sub-basin is not considered developable.

4. Mill Creek - part of the Lower Green River Sub-Basin

5. Miller Creek - part of the Lower Puget Sound Sub-Basin

For each demonstration area, more detailed data was obtained regarding the existing drainage system and the existing land use. With the additional data, it was possible to obtain more detailed analysis of urban runoff within the demonstration areas.

Special public meetings were conducted within the various demonstration areas for the purpose of examining alternative approaches to drainage design. Based upon the results of these meetings, alternative plans were developed which best satisfied the physical requirements of the area and the preferences expressed by local citizens.

Following plan development, citizens and local agencies again reviewed the alternatives. The alternatives were evaluated using the matrix. A completed matrix is presented for each of the alternative plans considered for the demonstration areas.

For each demonstration area, certain features of the alternative drainage plans are desirable for early implementation. These features, or facilities, are needed to correct present problems, and those predicted to occur during the next ten years, that are urgent and severe. The present and future drainage problems were identified as previously described. Computer simulations of existing drainage systems under existing land use were made to determine peak flow rates, to verify the reported problems, and to better determine the extent and severity of the problems.

The physical facilities suggested for early action have been placed into the three categories defined as follows:

1. CATEGORY I - COMMON ALTERNATIVE ELEMENTS. Certain provisions for drainage control are common to all reasonable alternatives proposed for that demonstration area. Early action can begin for these features as it is reasonable to assume that they eventually will be necessary and are therefore compatible to any future course of action.

2. CATEGORY II - ALTERNATIVE ELEMENTS COMMON IN SCOPE. In each demonstration area, there are elements that are common to all alternatives set forth, but which differ only in the size of facility required. For example, if one alternative proposes a "three-barrel" culvert at a certain location and the other alternative would have two, then it is reasonable to assume that one or two "barrels" installed to mitigate an urgent problem would continue to be useful in the long term.

3. CATEGORY III - RESPONSE TO REPORTED DRAINAGE PROBLEMS. A problem that might be minor, relative to the overall alternative drainage plans, both in terms of cost and potential consequences, can be a major problem for an individual or group of residents. Each jurisdiction should establish a temporary procedure for responding to reports of problems and citizen complaints until a permanent maintenance and operations arm of a future management entity can be formulated and funded.

The demonstration area descriptions also contain an estimate of reported annual property damages as obtained from local agencies. These estimates probably are far from complete and tend to greatly underplay the magnitude of the real financial and property loss.

This section contains descriptions and possible alternative plans for the following two demonstration areas within the Green River Basin and draining directly to Puget Sound. They are bound following the Regional Sub-Basin descriptions.

Mill-1	Mill Creek Demonstration Area
Miller-1	Miller Creek Demonstration Area

REGIONAL SUB-BASIN PLANS

REGIONAL SUB-BASIN G-2

NEWAUKUM CREEK

GENERAL DESCRIPTION

The Newaukum Creek Sub-Basin is located south of the upper Green River Valley. The headwaters of Newaukum Creek are springs in the Enumclaw Mountain area east of Enumclaw. The creek falls over its 14-mile length from an elevation of over 2500 feet above sea level to an elevation of approximately 200 feet where it joins the Green River (see Sub-Basin G-4). Most of the sub-basin is within the Enumclaw Flood Control Zone District.

Stream	Category	Drainage Area	Discharge
Newaukum Creek	II	27.0 sq. mi.	Green River

Land in the sub-basin is used predominately for timber production and agricultural purposes. The City of Enumclaw is presently the only significant urban area. Future development probably will result in mainly rural-residential and agricultural land uses.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	20	30	30
Multiple Family			
Commercial/Services	2	2	2
Govt. and Educ.			
Industrial			
Parks/Dedicated Open Space			
Agriculture	30	30	30
Airports, Railyards, Freeways, Highways			

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Unused Land	48	38	38
Water			
Total	100	100	100
Total Impervious Area	5	15	15

NATURE OF EXISTING DRAINAGE SYSTEM

The main feature of the existing drainage system is Newaukum Creek. All runoff leaving the sub-basin is eventually conveyed by the creek. Newaukum Creek begins in a fairly steep zone, passes through a moderately-sloped pastoral zone north of Enumclaw, and enters a deep steep-sided ravine before reaching the Green River. The creek is considered by the Department of Fisheries to be the second most important salmon and steelhead spawning creek in the Green River system. There are several areas along the creek where the severity of erosion is increasing as the sub-basin urbanizes.

The major man-made drainage facilities in the basin are within Enumclaw. A partial storm drain and roadside ditch system drains storm water from Enumclaw to Newaukum Creek.

DRAINAGE PROBLEMS

Because of the rural nature of the Newaukum Creek sub-basin, it has not presented major flooding problems. Those problems that have occurred are mainly localized flooding in the Enumclaw area and some erosion along the creek itself. However, because the flood plain of the creek generally has not been built upon, major flooding has not occurred.

As the sub-basin develops further, the magnitude and frequency of flooding could increase substantially. The problems that will develop can be classified into two major types: 1) flooding and erosion along the natural creek system and 2) continued, local off-stream flooding due to clogged culverts, high groundwater and mild slopes. Alleviation of the latter type of problem is dependent more upon maintenance procedures and site selection for development than upon basin-wide drainage planning. The first type of problem, however, can be reduced greatly by effective drainage planning. The section of the creek which will be most subject to flood damage is the mildly-sloped region north of Enumclaw.

The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Land Use Plans.

Therefore, the drainage alternatives presented herein are applicable to both plans.

Both the year 2000 Comprehensive and Corridor land-use plans project an increase in impervious land area from the existing 5% to approximately 15%. This represents a sizable increase over existing land use and will be reflected in noticeable increase in runoff that must be carried by Newaukum Creek. This level of development, however, is far behind that expected for the more urban basins of the Puget Sound Region and should allow the stream to continue to be the main carrier of storm-water runoff. Model simulation indicates that the main channel in the area north of Enumclaw will be overtopped in a 10-year storm with year 2000 land use. In addition, erosion in the steeper sections of the creek downstream will become more severe.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

No area-wide drainage plan exists for the Newaukum Creek Sub-Basin. A regional wastewater collection and treatment plant has been developed for the Enumclaw-Buckley area. This will do much to eliminate contamination of surface waters, but flooding problems will continue in the Enumclaw area. The City of Enumclaw has tentative plans to use source springs for Newaukum Creek as a source of water supply. Should this occur, low flows in the creek could be substantially reduced.

Representatives from the Enumclaw Flood Control District and the King County Department of Public Works, Hydraulics Division, were consulted during development of the alternative plans described below to assure that the existing system and problems were properly identified and that the proposed solutions were compatible with stream capabilities and runoff-control potentials within the sub-basin.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the sub-basin, as described by local agencies was evaluated by computer simulation that applied the region's 10-year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided for development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

This alternative makes use of a conventional approach to stream flooding problems. Development will be allowed adjacent to the existing open watercourses and the main channel of Newaukum Creek will be enlarged.

Major Features

The most important aspect of this alternative is the channelization and streambank protection along Newaukum Creek. In some places where low banks exist, diking may be necessary.

Cost

The cost for this alternative is estimated to be $400,000.

ALTERNATIVE PLAN II

General Concept

This alternative emphasizes the preservation of Newaukum Creek in its present condition.

Major Features

The major aspects of this alternative are flood-plain zoning, streambank protection, and a holding pond in the vicinity of S.E. 416th Street to control runoff entering the creek.

Cost

The cost for this alternative is estimated to be $300,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities, and with alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
Entering Green River	850	950	700
S.E. 400th Street	600	700	500
Enumclaw-Black Diamond Rd.	500	550	450

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

As part of the process of developing system proposals for the various regional sub-basins in the RIBCO study, field inspections were

made to judge applicability of the suggested alternatives for each sub-basin. The inspections were made on the basis of the alternative evaluation procedure which identified 34 unique criteria under the general categories of 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. In addition, projected land uses were reviewed for compatibility with the proposed systems. The various structural solutions were checked against the appropriate evaluation criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future land-use developments.

The Newaukum Creek criteria rating total for Alternative Plan I, which employed channelization and streambank protection, was a minus 26 on a scale ranging from positive 108 to a negative 108. The criteria rating total for Alternative Plan II, which employs storage and flood-plain zoning, was a plus 73.

In all five categories, Alternative Plan II received a higher rating, although implementation difficulty for the alternatives is considered to be about equal. The effectiveness of Alternative Plan II, which employs the major storage pond, is clearly superior to Alternative Plan I and the human values fostered by Alternative Plan II, which allows Newaukum Creek to be untouched by any structural solution, is again clearly superior to the structural solution contemplated in Alternative Plan I. Alternative Plan II received a nearly perfect score for environmental factors as opposed to Alternative Plan I which requires extensive alternation of the natural system and potentially disastrous effects upon wildlife, vegetation and aquatic life.

Alternative Plan II relies upon flood-plain zoning and storage to achieve the controllable volumes within Newaukum Creek. Alternative Plan II, should it be chosen for implementation, would require early action to protect the major storage area and the projected flood plain from encroaching development.

CONCLUSIONS

Because of the relatively undeveloped nature of this sub-basin, Alternative Plan II is clearly superior to Alternative Plan I. There is a certain urgency about implementing Alternative Plan II, should it be selected, as it relies on flood-plain zoning and the availability of storage within the sub-basin.

Both King County and the City of Enumclaw should work towards agreement for development of a master plan that incorporates the provisions of Alternative Plan II and both agencies within their own jurisdiction should move to implement the required flood-plain zoning.

RUNOFF QUALITY SUMMARY
NEWAUKUM CREEK

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

			CONCENTRATION AT PEAK FLOW*				
LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth	I	950	4	1.6×10^5	.1	.3	0
	II	700	4	1.7×10^5	.1	.3	0

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

NEWAUKUM CREEK

ALTER- NATIVES	SUB TOTAL	Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost benefits ranking	SUB TOTAL	Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	SUB TOTAL	High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	SUB TOTAL	Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	SUB TOTAL	Energy	Materials	Land	Capital	RATING TOTAL
		EFFECTIVENESS									HUMAN VALUES								ENVIRONMENTAL FACTORS										IMPLEMENTATION							RESOURCE REQUIREMENTS				
		CRITERIA WEIGHT									CRITERIA WEIGHT								CRITERIA WEIGHT										CRITERIA WEIGHT							CRITERIA WEIGHT				
		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	-5									-1								-22										+5							-3					-26
II	+17									+11								+30										+7							+8					+73

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub-Basin Newaukum Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
6	Channel	15'	11,500'	2:1	4'	Channel	20' width 4' depth 2:1 side slopes	$48,000
9	Channel	16'	3,500'	2:1	4'	Channel	20' width 4' depth 2:1 side slopes	$12,000
11	Channel	12'	4,800'	2:1	4'	Channel	24' width 4' depth 2:1 side slopes	$49,000
26	Channel	12'	4,500'	2:1	4'	Channel	24' width 4' depth 2:1 side slopes	$45,000
37	Channel	12'	8,000'	2:1	4'	Channel	24' width 4' depth 2:1 side slopes	$81,000
39	Channel	6'	900'	2:1	4'	Channel	12' width 4' depth 2:1 side slopes	$5,000
5	Channel	15'	3,000'	2:1	4'	Channel	3' depth Streambank protection	$135,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $375,000

Round To: $400,000

EVALUATION MATRIX

BIG SOOS CREEK

ALTERNATIVES	SUB TOTAL	EFFECTIVENESS: Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	SUB TOTAL	HUMAN VALUES: Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	SUB TOTAL	ENVIRONMENTAL FACTORS: High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	SUB TOTAL	IMPLEMENTATION: Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	SUB TOTAL	RESOURCE REQUIREMENTS: Energy	Materials	Land	Capital	RATING TOTAL
		CRITERIA WEIGHT 1	4	3	2	4	4	4	2		CRITERIA WEIGHT 4	2	2	1	3	3	4		CRITERIA WEIGHT 4	4	4	4	4	2	4	4	4		CRITERIA WEIGHT 4	4	2	4	4	3		CRITERIA WEIGHT 3	3	2	2	
I	+3									+4								0										-1							0					+6
II	+21									+11								+26										-4							+10					+64

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Big Soos

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
8	Channel	10'	1,600'	2:1	3'	Channel	15' width 4' depth 2:1 side slopes 1,000' bank protection	$60,000
11	Channel	30'	7,000'	2:1	4'	Channel	40' width 4' depth 2:1 side slopes 3,000' bank protection	$200,000
15	Channel	5'	3,600'	2:1	2'	Channel	8' width 2' depth 2:1 side slopes 1000' bank protection	$25,000
17	Channel	20'	6,500'	2:1	4'	Channel	40' width 4' depth 2:1 side slopes 1000' bank protection	$275,000
21	Channel	15'	5,500'	2:1	4'	Channel	30' width 4' depth 2:1 side slopes	$75,000
22	Channel	15'	4,400'	2:1	4'	Channel	30' width 4' depth 2:1 side slopes	$60,000
26 27	Channel	10'	3,200'	2:1	3'	Channel	14' width 3' depth 2:1 side slopes 1,200' bank protection	$50,000
30	Channel	10'	2,000'	2:1	3'	Channel	12' width 3' depth 2:1 side slopes 700' bank protection	$25,000
38	Channel	10'	2,900'	2:1	3'	Channel	12' width 3' depth 2:1 side slopes 500' bank protection	$20,000
39	Channel	10'	1,900'	2:1	3'	Channel	12' width 3' depth 2:1 side slopes 500' bank protection	$20,000
41	Channel	30'	1,200'	2:1	4'	Channel	1,200' bank protection	$50,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $860,000
Round To: $900,000

REGIONAL SUB-BASIN G-3

BIG SOOS CREEK

GENERAL DESCRIPTION

The Big Soos Creek Sub-Basin is located between the urbanizing southern portions of the metropolitan Seattle area (Kent and Auburn) and the rural/agricultural upper Green River Valley. Most of the sub-basin is in unincorporated King County, except along the western boundary, which is within Renton, Kent and Auburn. The City of Black Diamond is to the east.

The sub-basin consists of a complex system of streams tributary to Big Soos Creek. Several drain relatively large areas and become significant watercourses before entering Big Soos Creek. A number of significant lakes form a part of the natural drainage system.

Stream	Category	Drainage Area	Discharge
Big Soos Creek	I	72.0 sq. mi.	Green River
Little Soos Cr.	I	4.0 sq. mi.	Big Soos Creek
Covington Creek	I	20.4 sq. mi.	Big Soos Creek
Jenkins Creek	I	15.1 sq. mi.	Big Soos Creek
Rock Creek	I	1.5 sq. mi.	Lake Sawyer

Land use in the sub-basin is predominantly rural-residential and agricultural. Much of the area is vacant, forested land, but the sub-basin includes a rapidly developing suburban area. Future land use will be mainly single-family residential with accompanying commercial areas.

Development directly adjacent to Big Soos Creek itself has been limited somewhat by soil conditions. In several locations, the Creek's flood plain is composed of poorly-drained organic soils that are unsuitable for septic tank drainfield systems. As a result, very little development has been allowed on land directly adjacent to the creek. This may change, however, as wastewater collection systems are installed.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	P.S.G.C. Land Use Projection Corridor
Single Family	30	40	40
Multiple Family		< 1	< 1
Commercial/Services	< 1	< 1	< 1
Govt. and Educ.	< 1	< 1	< 1
Industrial		< 1	< 1
Parks/Dedicated Open Space	5	5	5
Agriculture	20	10	10
Airports, Railyards, Freeways, Highways			
Unused Land	43	42	42
Water	1	1	1
Total	100	100	100
Total Impervious Area	10	15	15

NATURE OF EXISTING DRAINAGE SYSTEM

The existing drainage system consists almost entirely of natural streams, roadside ditches, and culverts. The only storm-drain systems are within individual subdivisions and these drain to nearby streams or lakes.

The watercourses in the sub-basin are in a relatively natural condition, although indications of increasing flow rates and erosion are evident. Big Soos Creek is the most important salmon producing stream in the Green River System. The clear water and gravel beds in the creek and its tributaries provide an environment necessary for spawning and rearing of anadromous fish. The Green River State Fish Hatchery is located along the lower Big Soos Creek and captures many of the spawning salmon on the creek. However, in addition to hatchery production, the creek upstream of the hatchery accommodates runs of coho salmon, steelhead, and sea-run cutthroat trout.

Numerous lakes and swamps that are especially important for limiting runoff rates exist throughout the sub-basin. Lake Sawyer, Lake Meridian, Lake Morton, Pipe Lake, and Wilderness Lake are the major lakes. There has been extensive development around these lakes, but since the developing areas drain to the lakes, changes in downstream flows have been mitigated somewhat.

Because of the remaining wetlands and the limited encroachment upon the creek system, the watercourses have remained sufficiently undisturbed so that they are important fisheries streams as well as an aesthetic natural asset.

DRAINAGE PROBLEMS

Existing drainage problems in the sub-basin have been observed by King County maintenance personnel and field study investigators. The major problems are debris deposition, occasional flooding, and erosion along Big Soos Creek and its tributaries. Specific problems have been reported along portions of Little Soos, Jenkins Creek, and along the Lake Meridian waterfront. These problems most likely will worsen as urbanization progresses. If major developments install conventional storm drain systems that discharge to the small streams and ditches, erosion and flooding could damage salmon production and aesthetic values significantly. Also, construction directly adjacent to the creeks could cause similar effects.

The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Land Use Plans. Therefore, the drainage alternatives presented herein are applicable to both plans. As described in the table of existing and projected land uses, a relatively small increase in impervious area is expected for the Big Soos Creek Sub-Basin. Development is expected to increase the impervious land area from an existing 10% to approximately 15% in the year 2000.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

Presently, there are no major storm-water management plans for this sub-basin. Plans do exist for extending wastewater collection through most of the sub-basin. It is within the Metro service area and portions at the north end of the sub-basin already are served by Metro facilities.

The initial alternative plans were developed for the Big Soos Sub-Basin after consultation with staff members from King County Public Works Department, Hydraulics Division.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of Big Soos Creek Sub-Basin as described by local agencies was evaluated by computer simulation that

applied the region's 10-year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

This alternative consists of enlargement of channel capacities with no facilities for reduction of runoff rates or management of development. It is assumed that the lakes in the sub-basin will be maintained at as near to constant levels as possible and no provisions will be made for storage during major storms.

Major Features

The most significant features of this alternative are channel excavation and streambank protection. Also included are improvements to the Lake Meridian outlet channel to allow better control of the lake level.

This alternative will reduce flooding problems, but also will alter the stream channel to an extent that fisheries values will be impaired. Increased sediment load during excavation and higher resultant velocities could significantly interfere with spawning.

Cost

The cost for Alternative Plan I is estimated to be $900,000.

ALTERNATIVE PLAN II

General Concept

This alternative is directed towards preservation of existing stream channels by controlling runoff rates and maintaining a natural flood plain.

Major Features

This alternative utilizes runoff control in the upstream portions of the sub-basin and flood-plain zoning along most of the major creeks. Where runoff control cannot substantially reduce existing problems, some channel work is required. Runoff-control facilities consist mainly of improved outlets for lakes throughout the sub-basin so that the levels of the lakes can be varied in a controlled manner during intense storms. The amount of variation required is never more than two feet, and less where development has encroached closely upon the lakeshore (such as at Lake Meridian).

This alternative would reduce flooding and preserve most of the existing stream system. In addition, further flow and damage reduction can be achieved by requiring runoff control from individual developments that drain directly to streams.

Cost

The cost of this alternative is estimated to be $200,000.

PEAK FLOW COMPARISONS

The following table indicates existing and probable future stream flows under the alternative drainage plans for year 2000 land use.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
Big Soos Creek	2,000*	2,200	1,650
Covington Creek	470	470	430
Jenkins Creek	570	720	650

*This calculated flow is higher than the gaged peak flow of 1,090 cfs. This is due to the lack of data regarding the natural drainage system which includes many lakes and wetlands that retard runoff. For developing alternatives, however, these flows are relative and indicate the proper order of magnitude.

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternative plans for this basin. This procedure was followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs channelization and streambank protection, is a plus 6 on a scale ranging from a positive total of 108 to a negative total of 108. The total evalua-

tion rating for Alternative Plan II, which employs storage, flood-plain zoning, some channelization and streambank protection, was a plus 64.

While both alternatives provide effective control of storm runoff, Alternative II is judged to be superior because of the positive prevention of erosion and sedimentation, the limited consequences of overcharge due to flood-plain zoning and the basic reliability of the system. Human values are promoted by both alternative plans. Again, however, Alternative Plan II has a higher rating. It should provide maximum aesthetic enjoyment in an urbanizing area as well as offer high potential for multiple use and strengthening of community cohesion through the potential for linear open spaces throughout the entire sub-basin. A greater disparity between the two alternative plans is seen in the analysis of environmental factors. While Alternative Plan I does not necessarily destroy or diminish natural conditions within the sub-basin, it does not have the positive enhancement features associated with Alternative Plan II. Alternative Plan II positively will affect water quality, low-flow conditions and should preserve or enhance the already high fishery potentials of the Big Soos Creek. Implementation of both alternative plans is considered to be difficult because of the multiplicity of jurisdictions involved. Resource requirements for Alternative Plan II are significantly less than Alternative Plan I, resulting in a positive rating for Alternative Plan II.

A critical element in Alternative Plan II is a proposal to use flood-plain zoning along the Big Soos Creek and its tributaries. This treatment, if it is to be part of the chosen alternative, should be implemented as an early organized effort of the involved agencies. Any development which occurs within the designated flood-plain areas, will force the use of more complex drainage-control features than Alternative Plan II contemplates. Alternative Plan II, in addition, relies upon control of runoff in new development not to exceed 25% over existing conditions. This provision, again, requires immediate attention by the involved agencies. These issues should be brought to the attention of all affected citizens and their local governments. It should also be understood that Alternative Plan II, because it suggests flood-plain zoning, would effectively remove that portion of the sub-basin within the designated flood-plain zone from any future intensive land uses typical of urbanized areas.

CONCLUSIONS

While both alternatives received positive ratings, Alternative Plan II is superior to Alternative Plan I because it does not require extensive structural work within the sub-basin and it insures water quality and low-flow conditions in the various tributaries.

King County, Cities of Renton, Black Diamond, Kent and Auburn should establish an effective agreement for a master drainage plan, incorporating the conditions of Alternative Plan II. All agencies

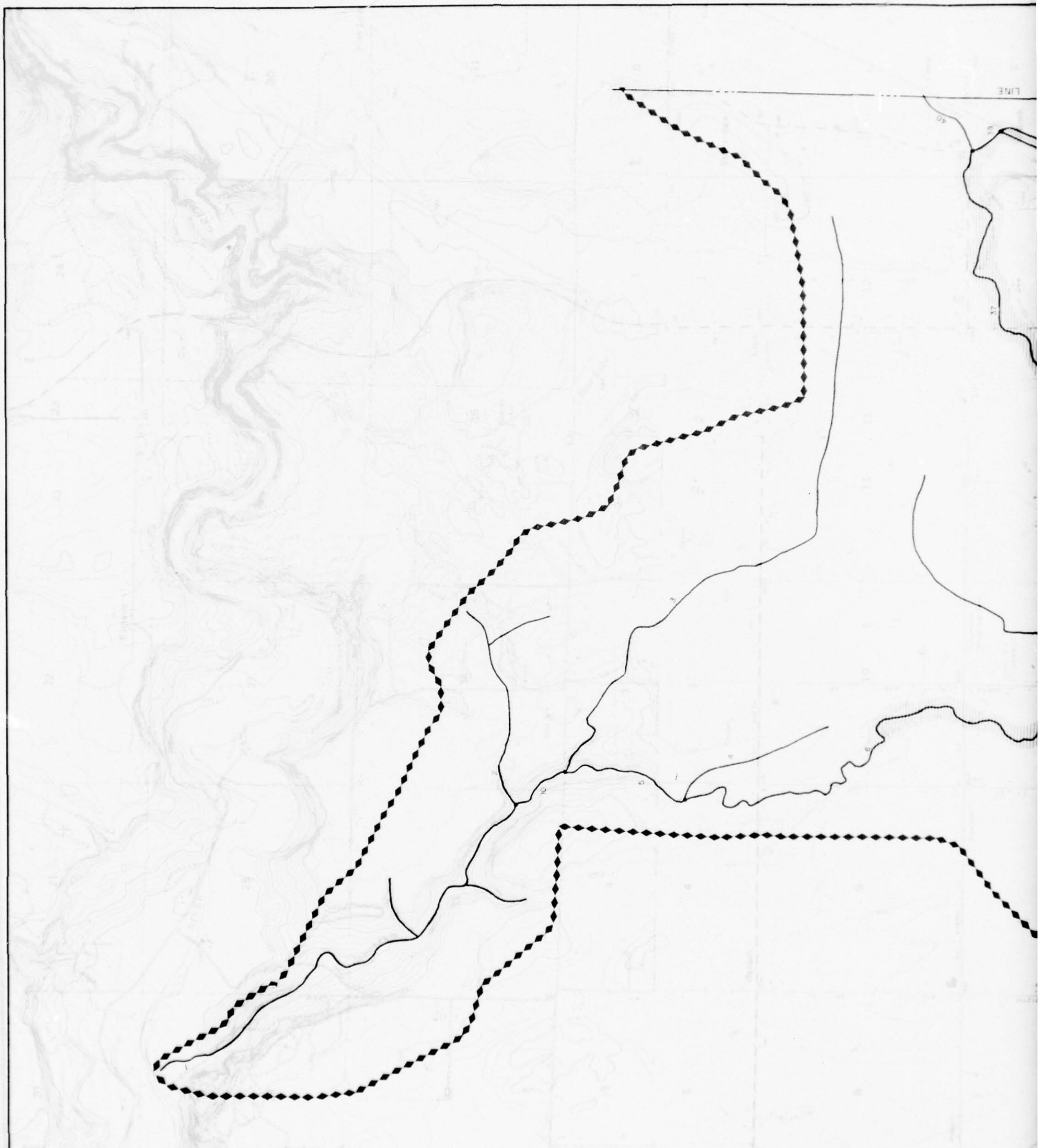
involved should then move to implement and enforce the required flood-plain zoning within their own jurisdictions and make provisions to ensure that runoff control is part of future development. Because of the extensive land area within the sub-basin controlled by King County, the County should have responsibility for control of drainage and flood damage within the Big Soos Sub-Basin; and the cities of Renton, Black Diamond, Kent and Auburn should have control of zoning, including flood-plain zoning, within their respective boundaries and concurrent jurisdiction in the outer fringe areas of the cities.

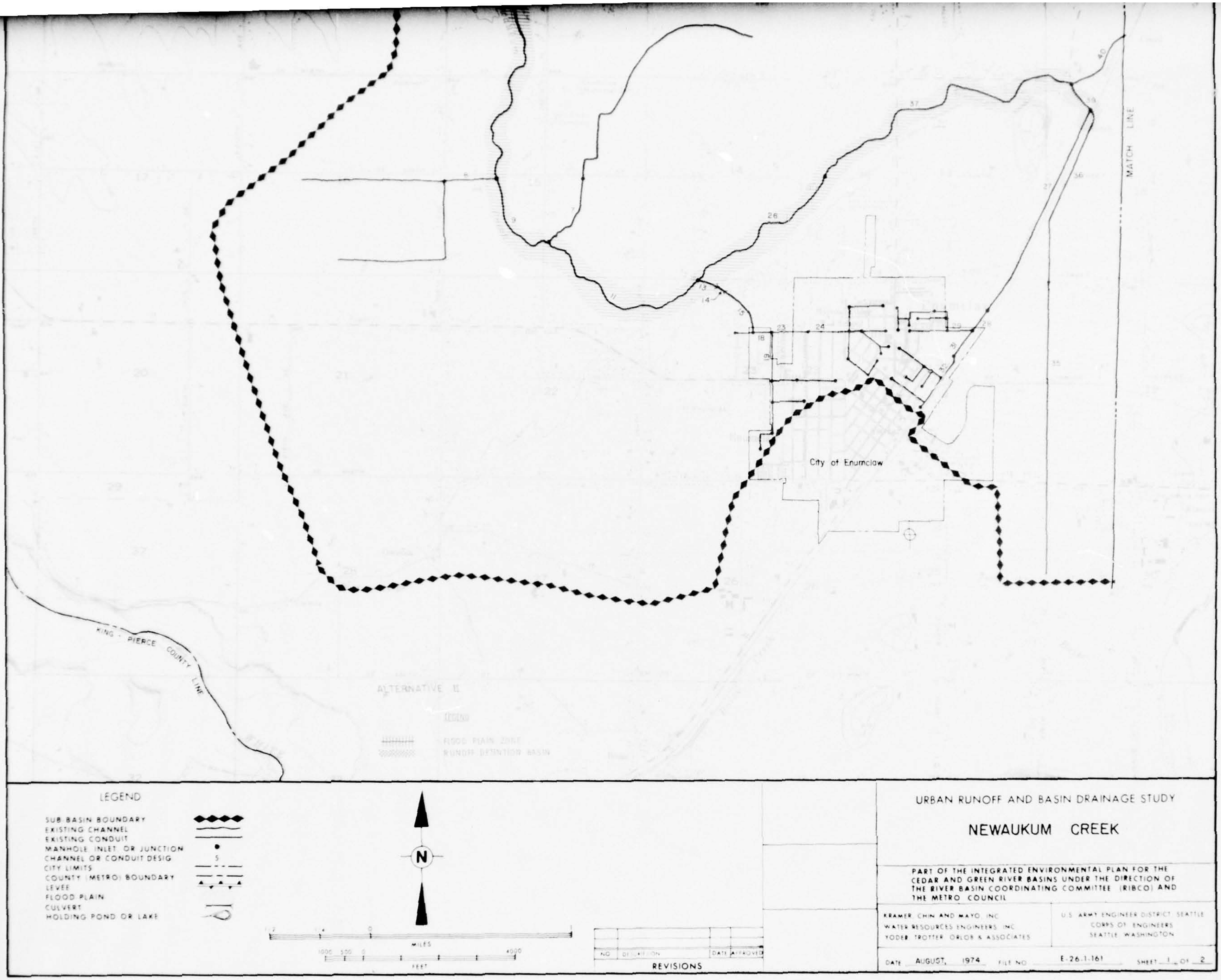
RUNOFF QUALITY SUMMARY
BIG SOOS

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth	I	2200	2	0.5×10^5	.04	.2	.02
	II	1650	3	0.6×10^5	.04	.2	.02

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.




MATCH LINE
City of Enumclaw
KING - PIERCE COUNTY LINE
ALTERNATIVE II
FLOOD PLAIN ZONE
RUNOFF DETENTION BASIN
LEGEND
SUB BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
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APPROVED
REVISIONS
URBAN RUNOFF AND BASIN DRAINAGE STUDY
NEWAUKUM CREEK
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
DATE AUGUST, 1974
FILE NO E-26-1-161
SHEET 1 OF 2

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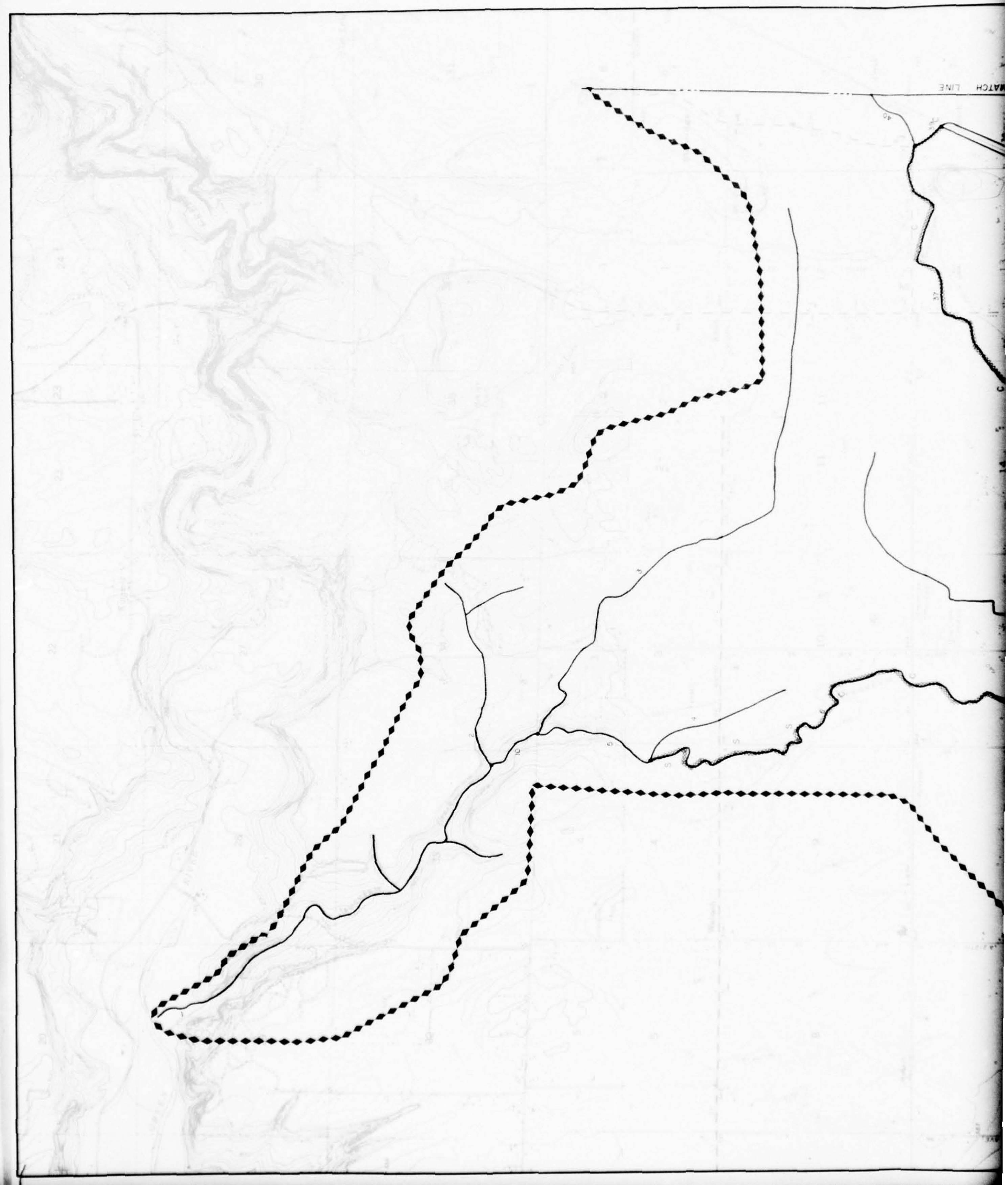
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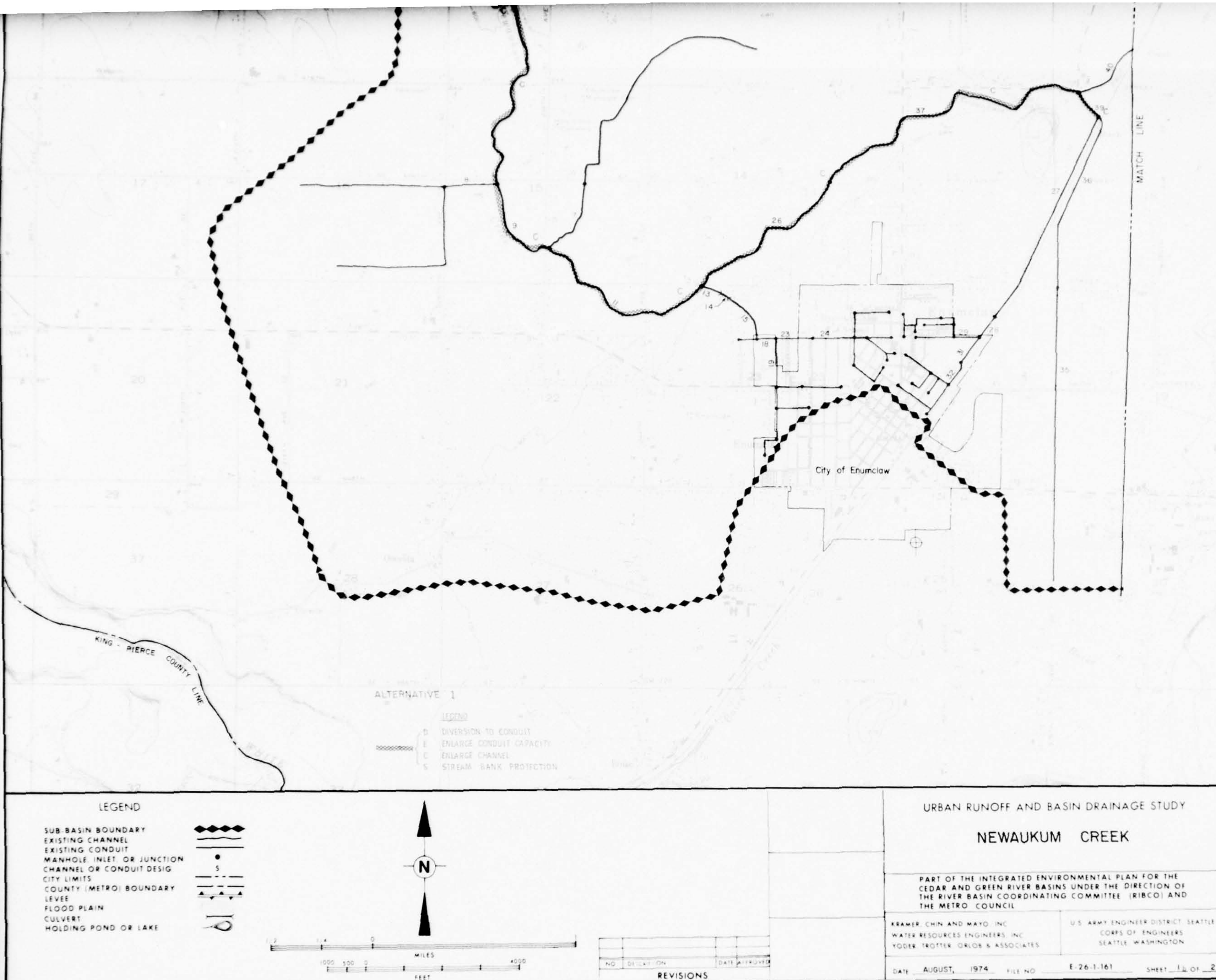

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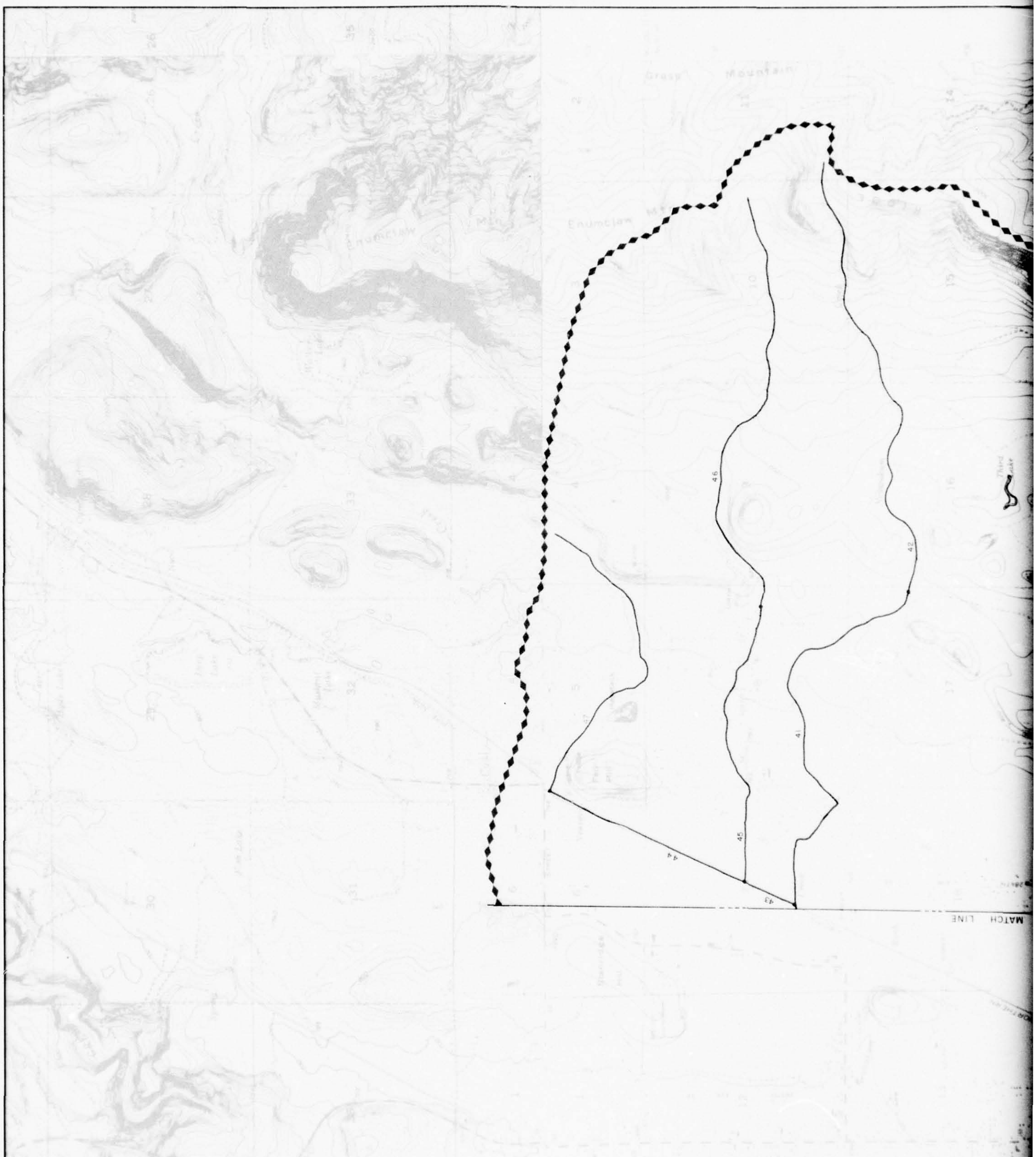

Grass Mountain
Enumclaw Mt
MATCH LINE
41
42
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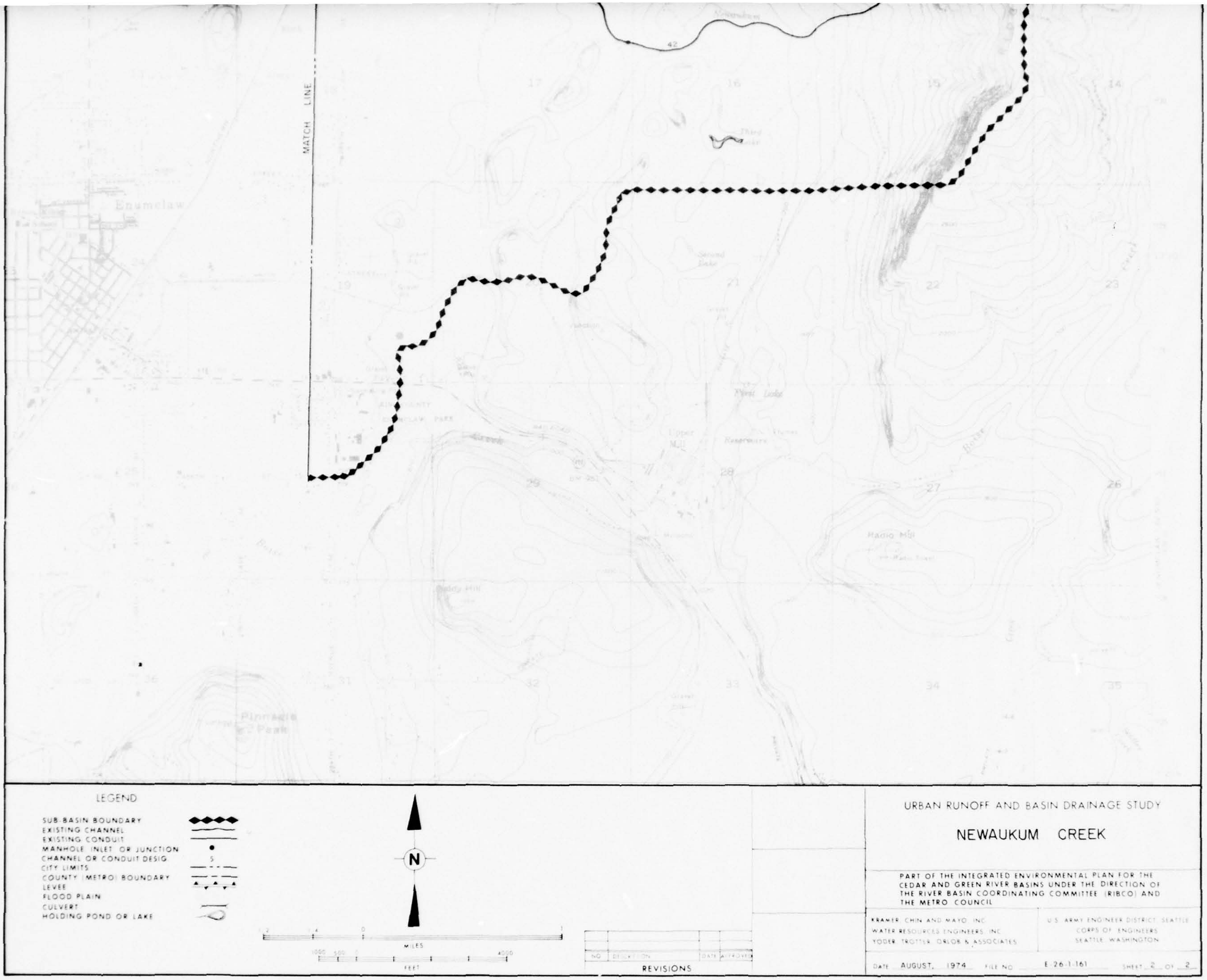

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NEWAUKUM CREEK

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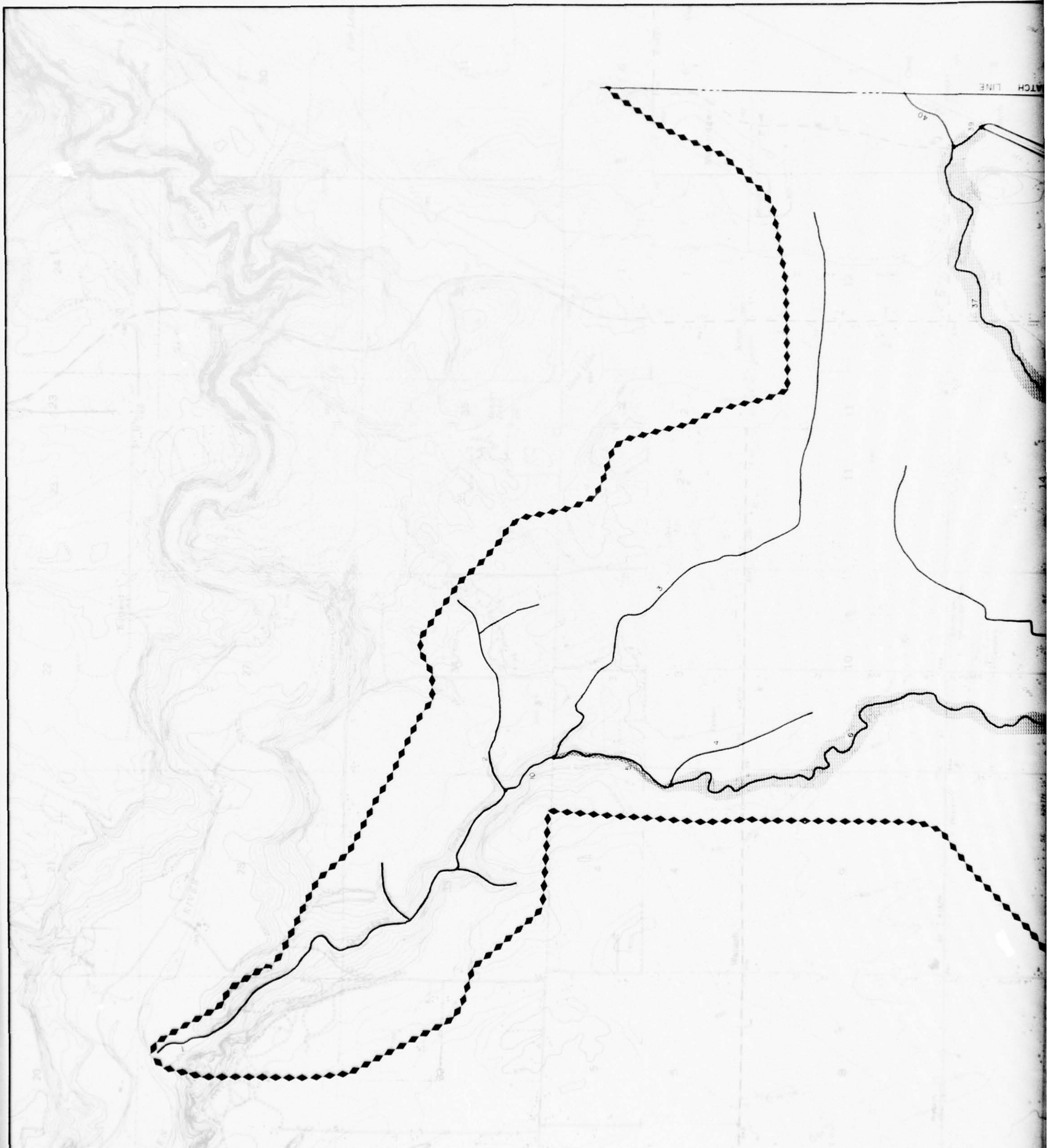

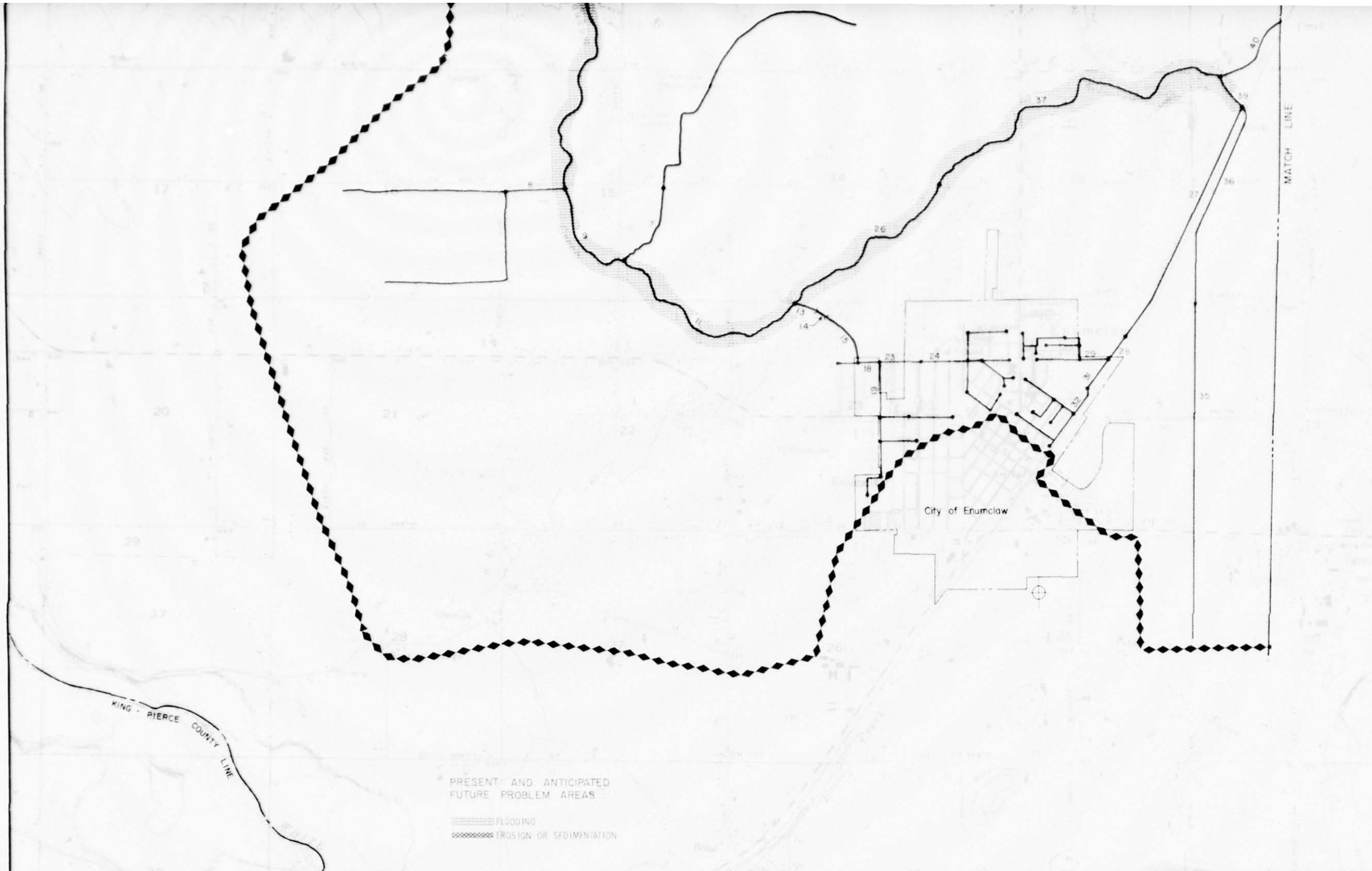

LEGEND

SUB-BASIN BOUNDARY
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MANHOLE, INLET, OR JUNCTION
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COUNTY (METRO) BOUNDARY
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NO	DESCRIPTION	DATE	APPROVED

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NEWAUKUM CREEK

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RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Newaukum Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
39	Channel	6'	900'	2:1	4'	Holding Pond	21 AF storage along ditch and railroad tracks	$182,000
5	Channel	15'	3,000'	2:1	4'	Channel	3' depth Streambank protection	$70,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $252,000

Round To: $300,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

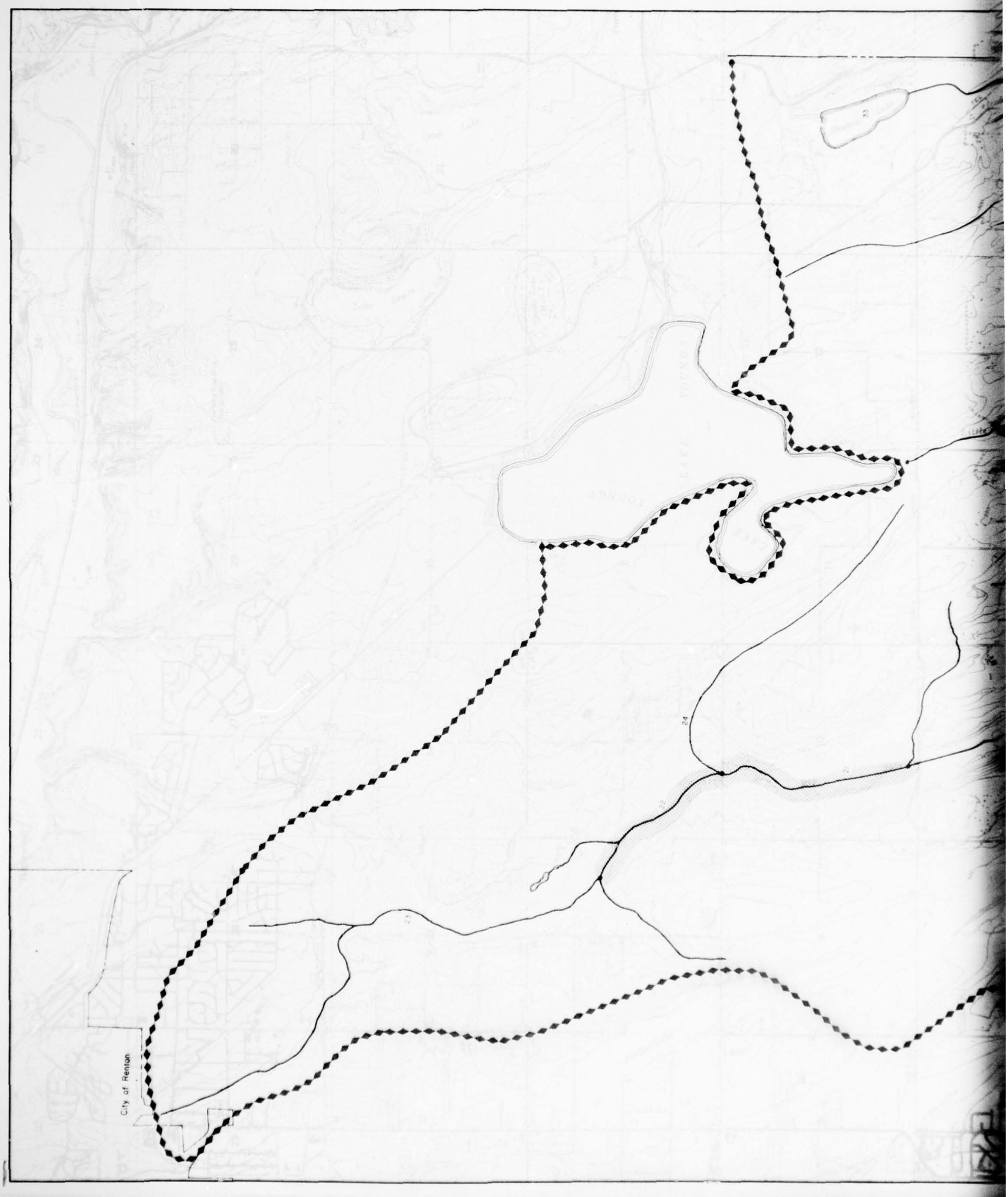
Alternative II Sub-Basin Big Soos

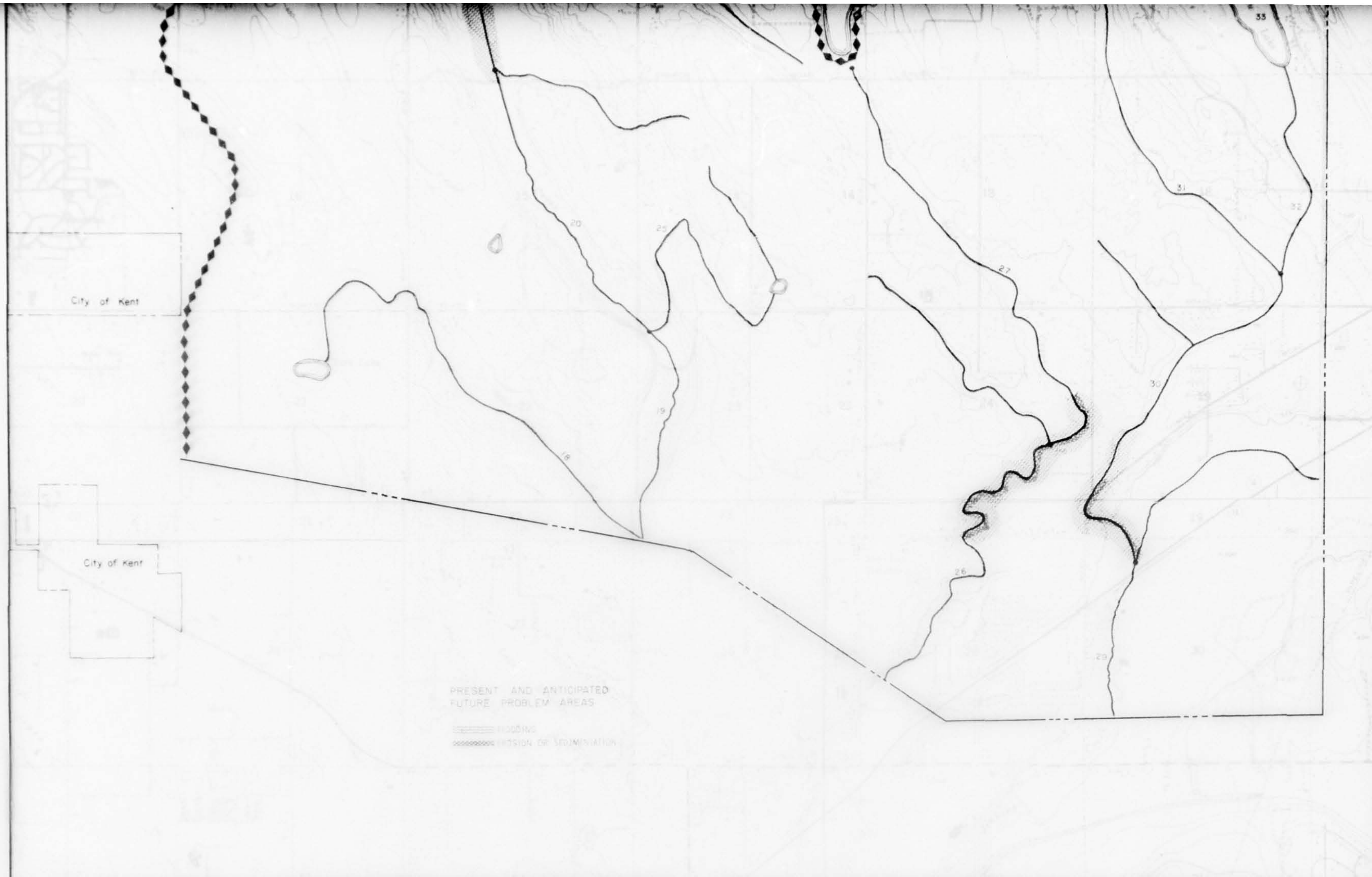
ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
8	Channel	10'	1,600'	2:1	3'	Detention Pond	20 AF 5 acres	$46,000
15	Channel	5'	3,600'	2:1	2'	Channel	8' width 2' depth 2:1 side 1,000' bank protection	$25,000
26 27	Channel	10'	3,200'	2:1	3'	Channel	14' width 3' depth 2:1 side 1,200' bank protection	$50,000
25	Pond and Wetlands					Runoff Detention Basin	15 AF of storage in existing pond and wetlands	$12,000
33	Shadow Lake					Runoff Detention Basin	Improve lake outlet structure and operate to provide 15 AF storage	$12,000
37	Wilder-ness Lake					Runoff Detention Basin	Improve lake outlet structure and operate to provide 5 AF storage	$12,000
40	Lake Lucerne					Runoff Detention Basin	Improve lake outlet structure and operate to provide 10 AF storage	$12,000
47	Lake Sawyer					Runoff Detention Basin	Improve lake outlet structure and operate to provide 62 AF storage	$22,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $191,000

Round To: $200,000


City of Renton
LAKE YOUNGS



LEGEND

SUB BASIN BOUNDARY
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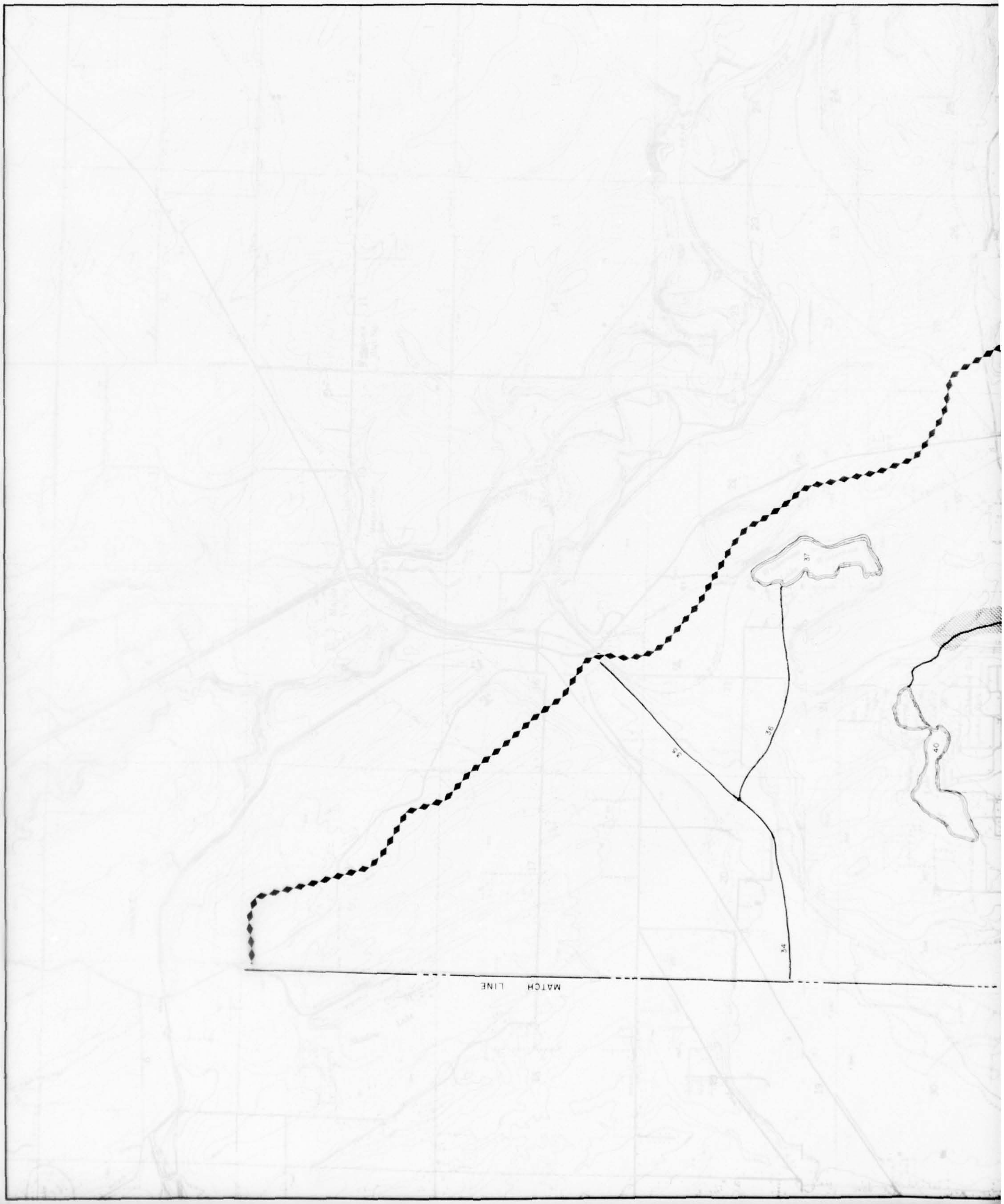
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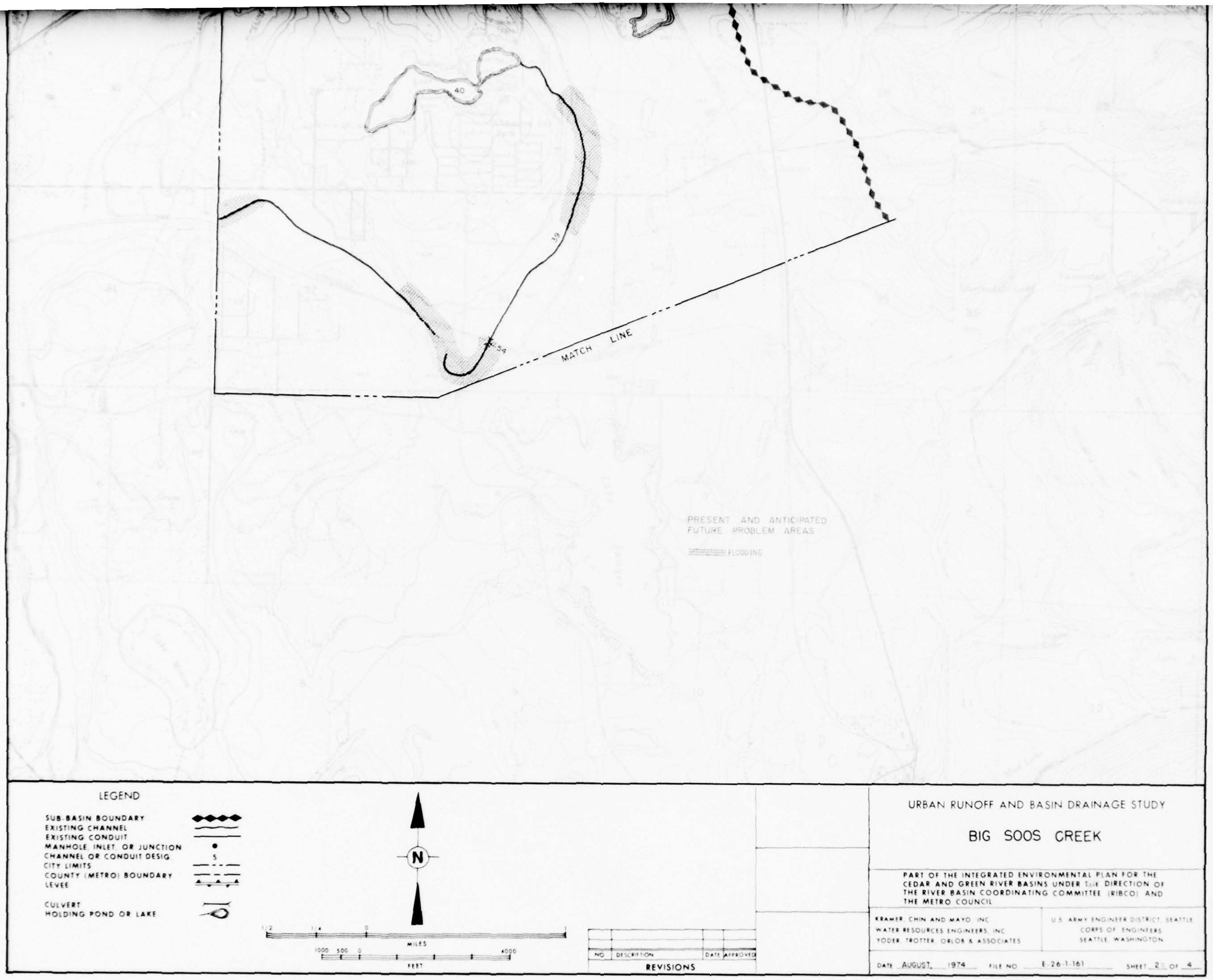

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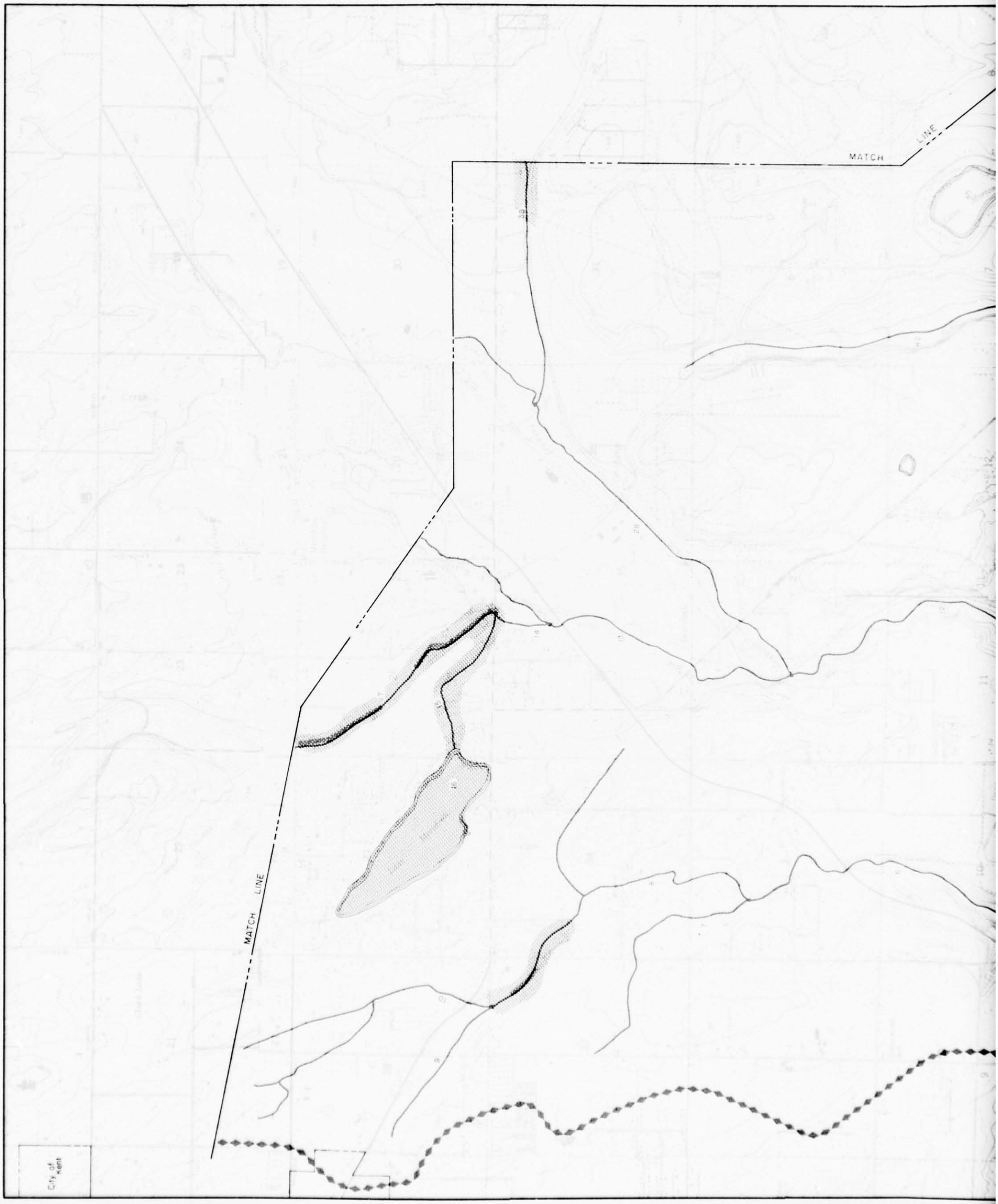

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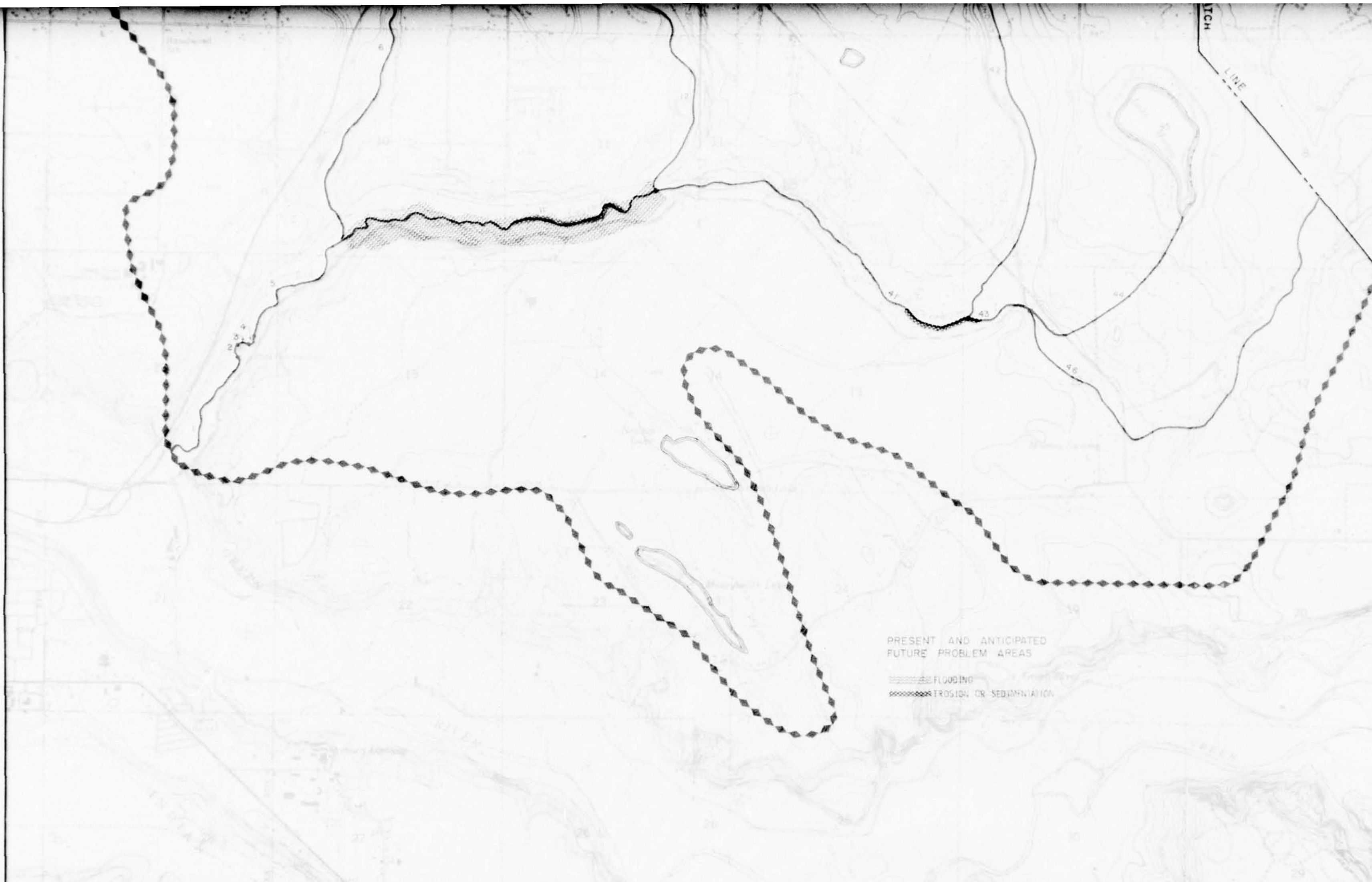

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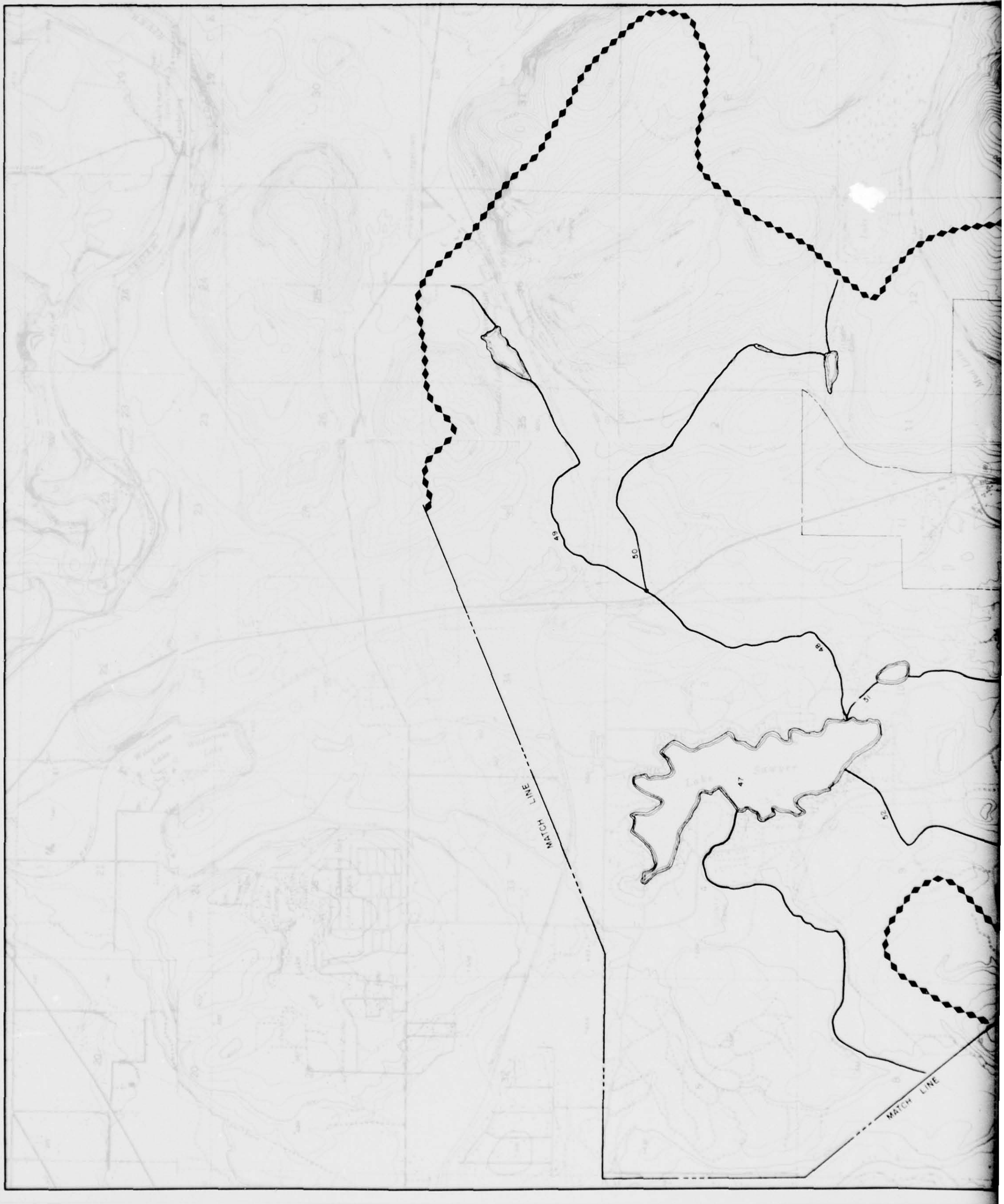
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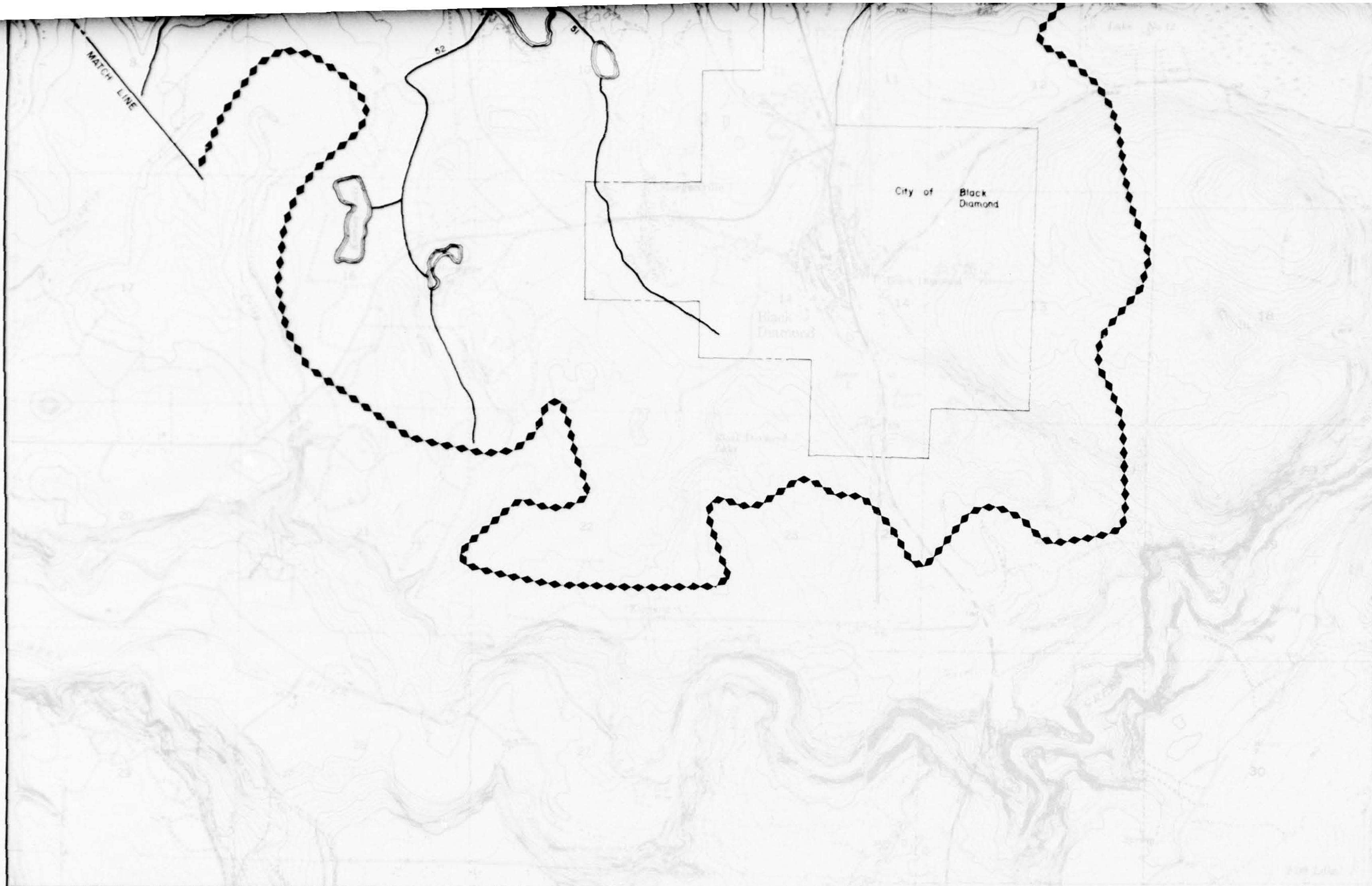

LEGEND

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- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- HOLDING POND OR LAKE

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NO	DESCRIPTION	DATE	APPROVED

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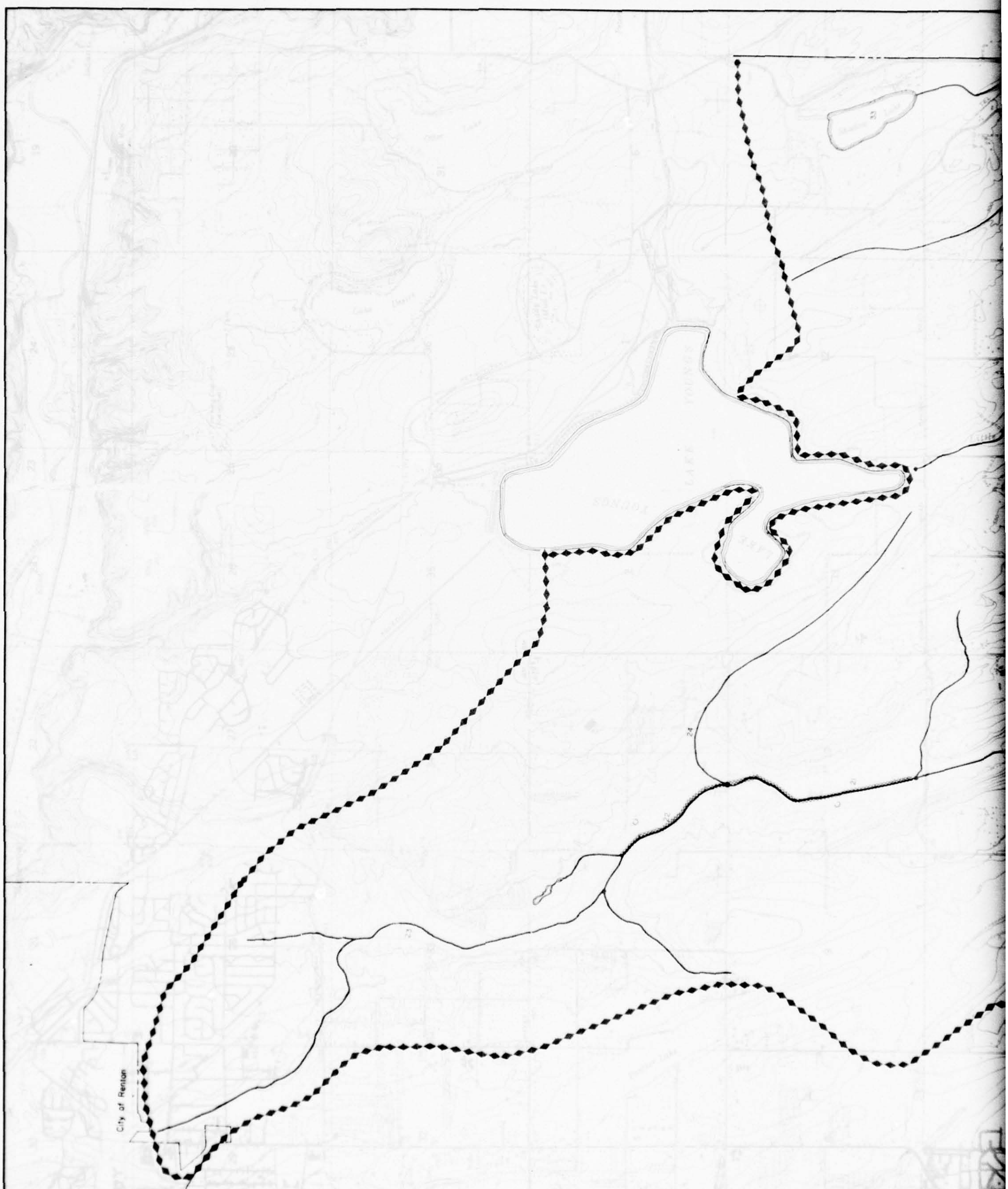
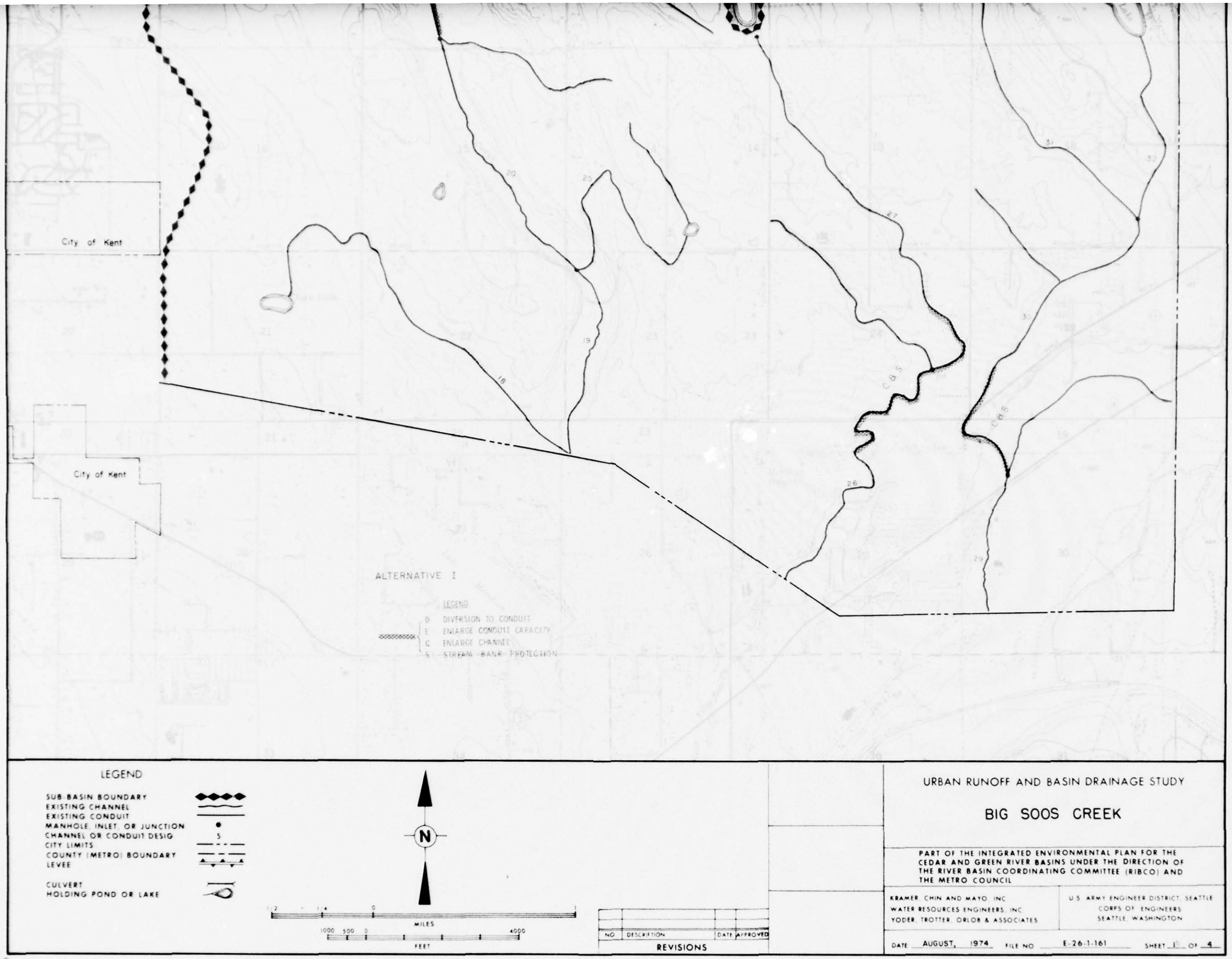

City of Renton


City of Kent
City of Kent
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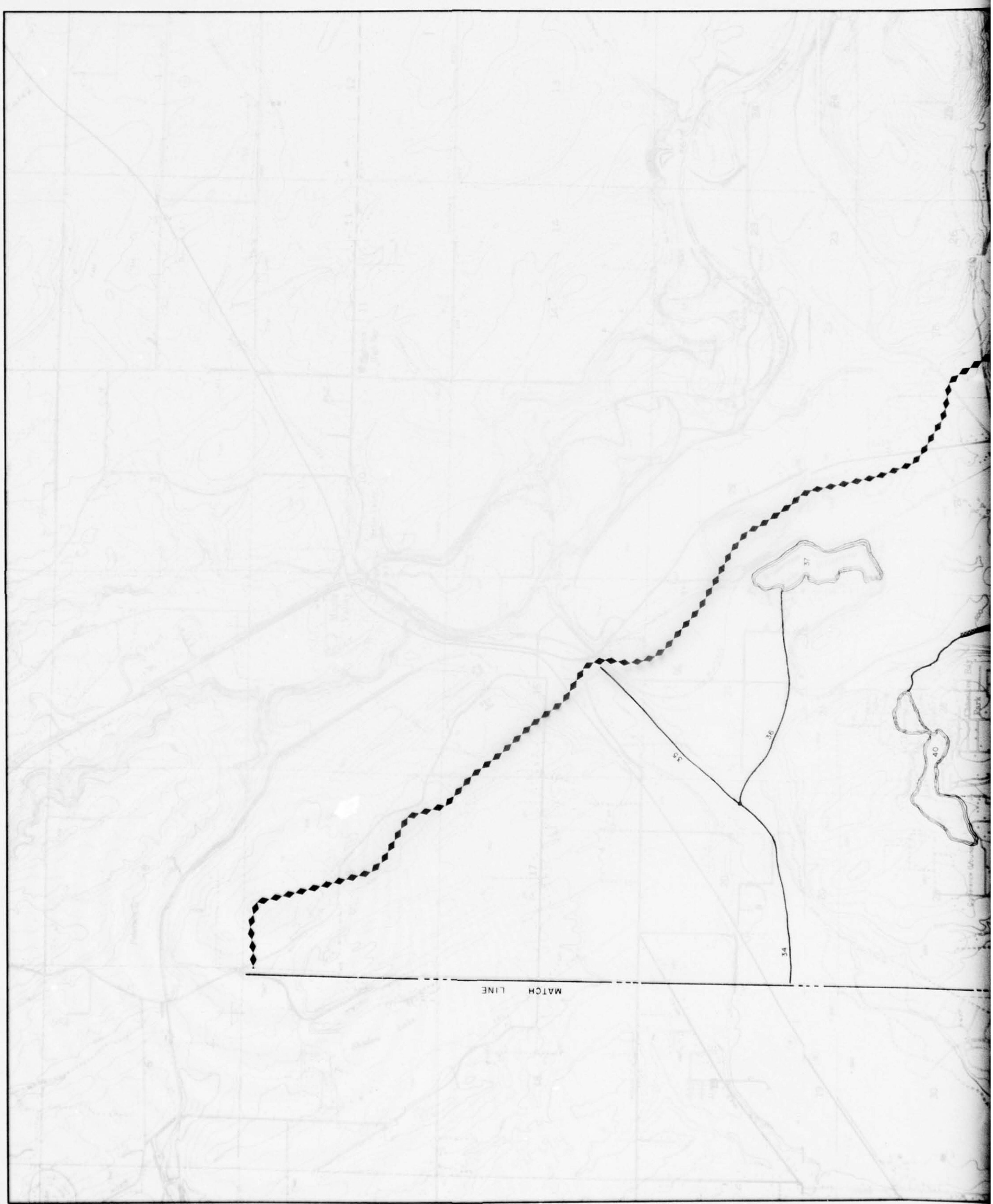
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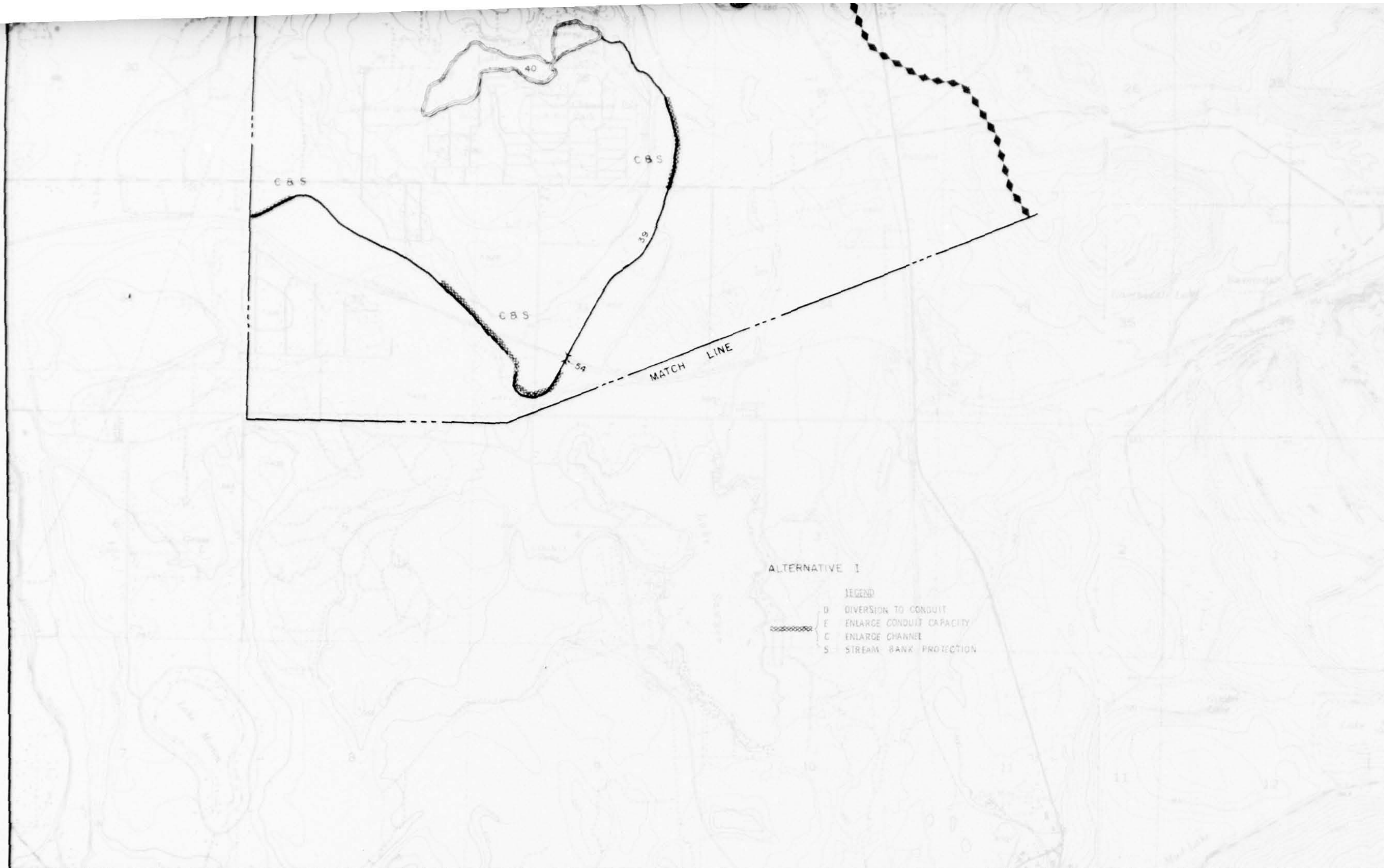

LEGEND

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MANHOLE, INLET, OR JUNCTION
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COUNTY (METRO) BOUNDARY
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HOLDING POND OR LAKE

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1000 500 0 4000 FEET

NO	DESCRIPTION	DATE	APPROVED

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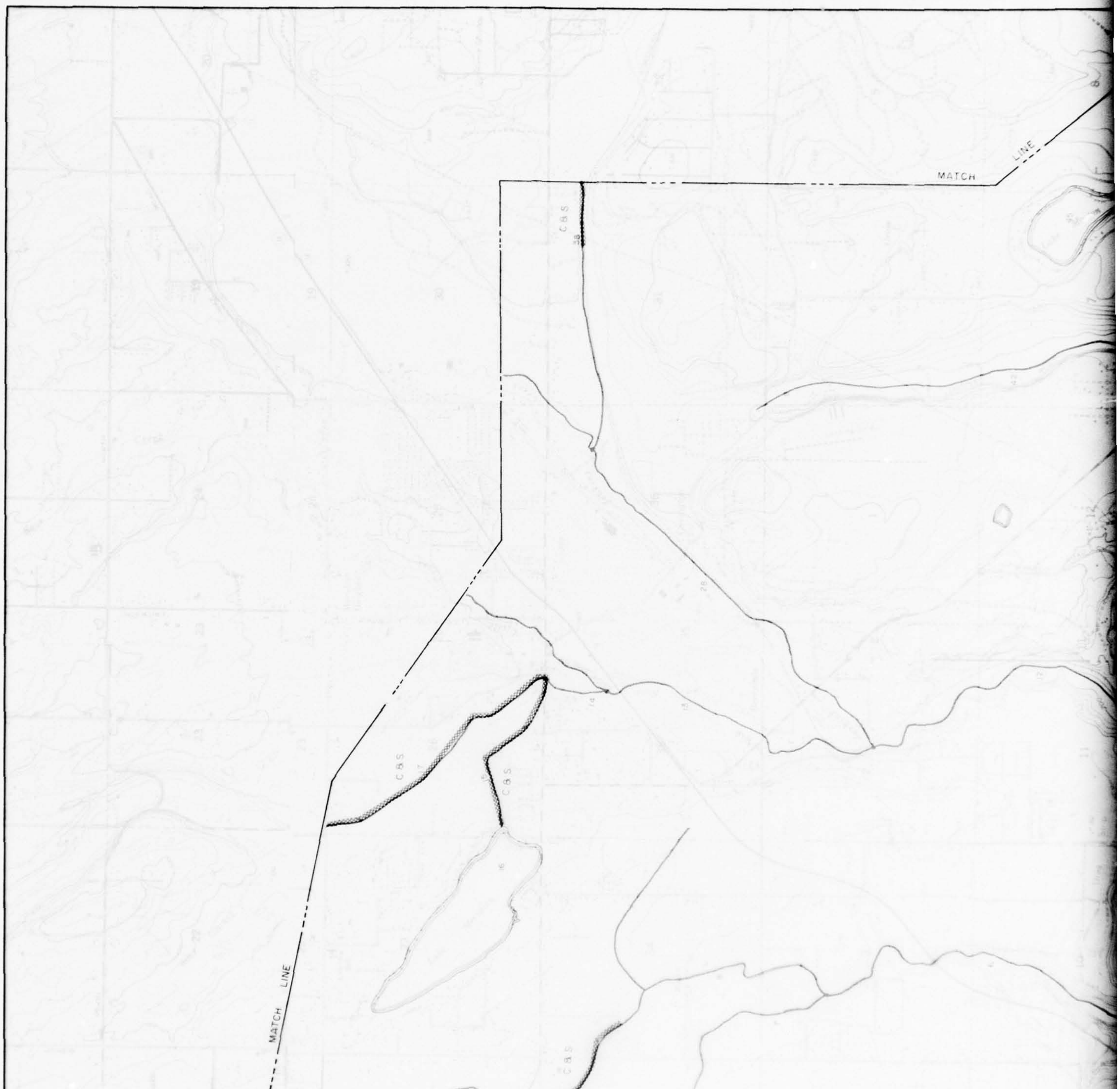
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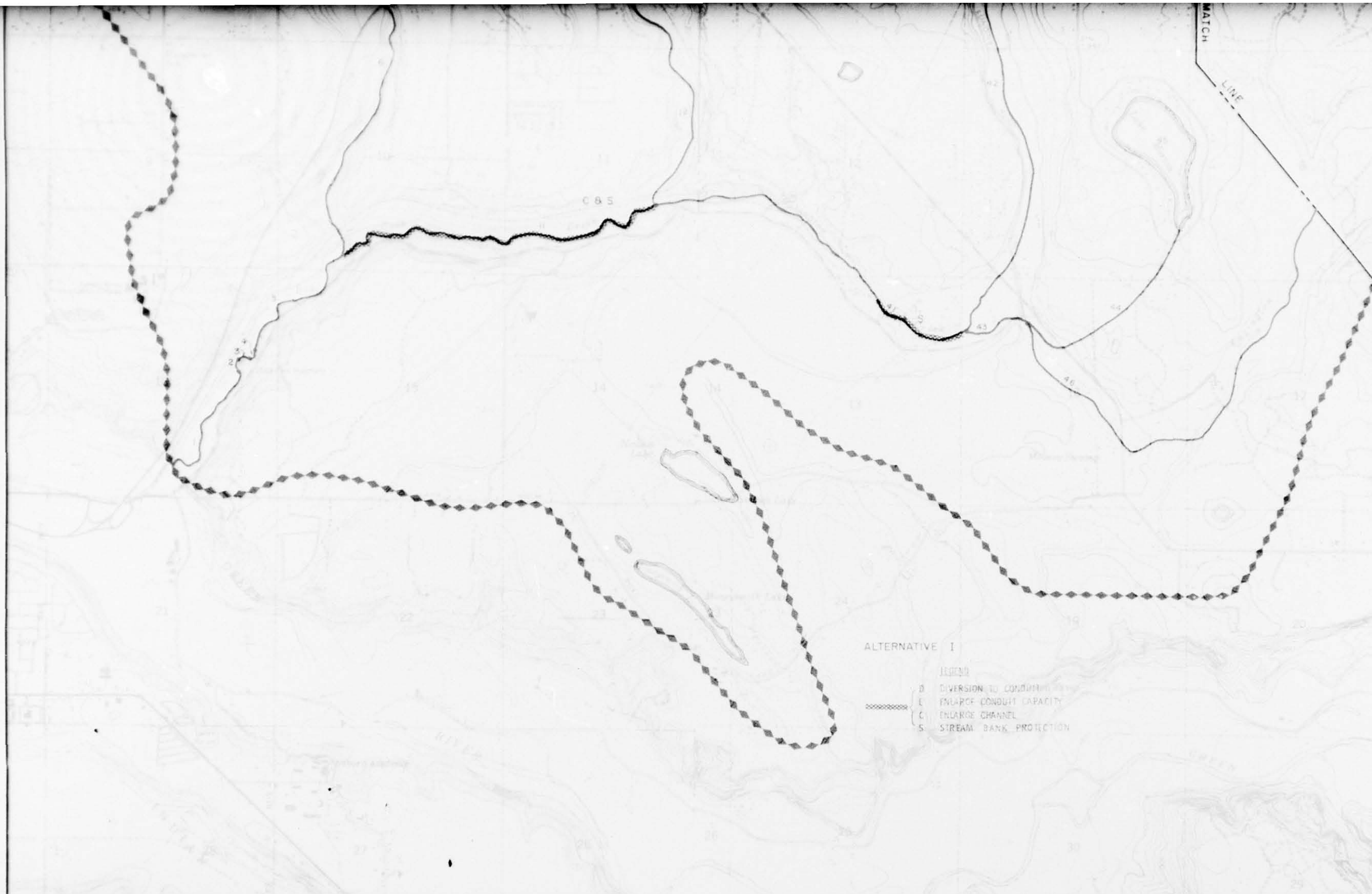

LEGEND

SUB BASIN BOUNDARY
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REGIONAL SUB-BASIN G-4

MIDDLE GREEN RIVER

GENERAL DESCRIPTION

The Middle Green River Sub-Basin includes the lands draining directly to the river from below the Howard Hanson Reservoir downstream to Auburn. The major topographic feature of the sub-basin is the Green River Valley. The upstream portions of the valley have a relatively wide floor that narrows downstream to form the scenic Green River Gorge. Downstream of the gorge, the valley widens again to form a broad, relatively flat, river bottomland. The major streams in the sub-basin, in addition to the Green River, are Coal Creek, Deep Creek and Crisp Creek. Both Coal and Deep Creeks are unusual in that they discharge to lakes that have no surface outlets but rather drain to the Green River through underground aquifers and emerge as springs.

The Newaukum Creek Sub-Basin enters the Green River in the lower gorge section and is a major tributary that could have a marked effect upon water quality in the Green River. Due to the size and importance of the Newaukum Creek drainage, it is treated separately by the RIBCO program and this study. The following table describes the category of streams within the Middle Green River Sub-Basin.

Stream	Category	Drainage Area	Discharge
Green River	I	67.0 sq. mi.	-
Coal Creek	I	14.2 sq. mi.	Fish Lake
Deep Creek	I	4.2 sq. mi.	Deep Lake
Crisp Creek	I	2.6 sq. mi.	Green River

Present development in the sub-basin is scattered. The largest portion of the sub-basin is undeveloped open space.. East Auburn comprises most of the urban area that presently exists within the sub-basin. A substantial portion of the western half of the sub-basin is used for agriculture. Future development probably will continue in a pattern similar to that which is already established. Most of the river bottomland will be used for agriculture and areas of higher elevation will be used for further residential development.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection	
		Comprehensive	Corridor
	Rural	Urban	Urban
Single Family	10	15	15
Multiple Family			
Commercial/Services		1	1
Govt. and Educ.			
Industrial			
Parks/Dedicated Open Space	10	10	10
Agriculture	15	10	10
Airports, Railyards, Freeways, Highways			
Unused Land	64	63	63
Water	1	1	1
Total	100	100	100
Total Impervious Area	3	7	7

NATURE OF EXISTING DRAINAGE SYSTEM

The major feature of the existing system is a 27-mile portion of the Green River. The river begins in a moderately-sloped zone, enters the steep boulder zone of the gorge, and then flattens to a floodway zone with a braided channel. Flows in the river are controlled to a large degree by the Howard Hanson Dam upstream.

Drainage systems in developed areas consist predominately of roadside ditches and culverts.

DRAINAGE PROBLEMS

The construction of Hanson Dam on the Green River has substantially decreased flooding problems in this sub-basin. Because the area is generally agricultural or is undeveloped, major damage seldom occurs. There are several areas where flooding problems do occur, however.

Some development has taken place and occasional flooding problems have occurred along Crisp Creek, Coal Creek, and Deep Creek in the community of Cumberland. The City of Auburn has had some slide problems in steep-sloped residential areas, but since most of the river's flood plain is agricultural land or open space, major flood damage does not occur. However, if substantial development were allowed to encroach upon the river, severe flooding problems could result.

As the sub-basin urbanizes, the effects of storm water runoff upon the Green River probably will be more significant in terms of quality than quantity. The river flow is high enough so that the added increase, brought about by residential development, will not be significant. However, the pollutants found in urban and agricultural runoff could degrade water quality in the river, especially during low-flow periods.

Minor drainage problems, such as culvert clogging and small-stream erosion, are presently at several sites in the sub-basin and will be continued with further development if more effective management is not provided. In order to prevent flooding in developing areas, conventional storm-drain systems probably will be installed. If not planned well, these systems could result in erosion and flooding problems along the small streams draining to the river.

The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Land Use Plans. Therefore, the drainage alternatives presented herein are applicable to both plans.

Land-use projections for the year 2000 indicate that a large portion of this sub-basin will remain forested. The total impervious area in this basin, with either land use projection, will increase from existing 3% level to approximately 7%, as shown in the table of projected land uses.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

Drainage planning that has been done for this sub-basin is contained in a study prepared by the King County Department of Planning in 1970 and titled, "The Upper Green River: An Ecological Study." This study is fairly complete and includes findings for flood control and storm drainage. The major recommendation of the study is that land use in the upper Green River Valley generally should be designated for agriculture rather than urban development. Also, the study recommends that individual development should be located so that the quality, quantity and velocity of storm runoff will approach natural conditions prior to entering surface watercourses.

Staff members from King County Public Works Department, Hydraulics Division have been consulted during preparation of the initial alternative plans for the Middle Green River.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Middle Green River Sub-Basin, as dedcribed by local agencies was evaluated by computer simulation that applied the region's 10-year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions provided in development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

This alternative consists of structural improvements to the creek channels and flood-plain zoning along the Green River.

Major Features

Improvements to the stream channels include cleaning, widening, and streambank protection in erosion-prone locations. Flood-plain zoning entails restrictions upon structural improvements directly adjacent to the Green River within the area of inundation by the most severe storm (100 year).

Cost

Cost for this alternative is estimated to be $100,000.

ALTERNATIVE PLAN II

General Concept

This alternative utilizes upstream runoff control rather than enlarged stream capacities. Flood-plain zoning is included for the Green River.

Major Features

The runoff-control facilities consist of both existing and new holding ponds. The existing pond is along Crisp Creek. The new ponds are adjacent to the railroad embankment along Coal Creek.

Cost

The cost for this alternative is estimated to be $100,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and with the alternative plans and year 2000 land use.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
Crisp Creek	50	80	40
Coal Creek	150	220	150
Deep Creek	80	110	60

ENVIRONMENTAL ASSESSMENTS OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternatives for this sub-basin. This process was followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements.

The various structural solutions were checked against the appropriate criteria, and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs channelization and flood-plain zoning, was a plus 24 on a scale ranging from a positive total of 108 and a negative total of 108. The total evaluation rating for Alternative Plan II, which employs storage in the upper sub-basin and flood-plain zoning, was a plus 75.

Both alternative plans were judged to be effective in controlling drainage. Both plans also registered positive ratings for human values and environmental factors. Neither alternative is part of the present planning of the involved agencies and therefore a cooperative effort is required before either plan can be realized. Both of the alternative plans involved limited commitment of the use and management of natural resources as they are basically non-structural in character.

One critical element in both alternatives is the proposal to use flood-plain zoning along the Middle Green River. This treatment, if it is to be part of the chosen alternative, should be implemented as an early organized effort. Any development that occurs within the flood-plain area, will force the use of a more structural treatment than either alternative contemplates. This issue should be brought to the attention of all affected citizens and their local agencies. It also should be understood that both alternatives, because they suggest flood-plain zoning, would effectively remove that portion of the sub-basin within the zone from any future intensive land uses typical of urbanized areas.

CONCLUSIONS

Alternative Plan II is superior to Alternative Plan I because it does not require more costly structural work along the streams in the basin. It does require immediate action, as it relies upon flood-plain zoning.

King County and the City of Auburn should develop master drainage plans, that incorporate the provisions of Alternative Plan II. Both agencies should then move to implement and enforce the required flood-plain zoning and make provisions to secure through acquisition, if necessary, the required storage areas.

King County, because of its extensive jurisdictional control, should have responsibility for control of drainage and flood damage within most of the Middle Green River Sub-Basin; and the City of Auburn and King County should have control of zoning, including flood-plain zoning, within their respective boundaries.

Development of the plan will benefit from coordination between the City and the County, but formal agreements are not mandatory since implementation of the plan in both City and County areas is generally independent of actions in the other jurisdiction.

RUNOFF QUALITY SUMMARY
MIDDLE GREEN RIVER

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

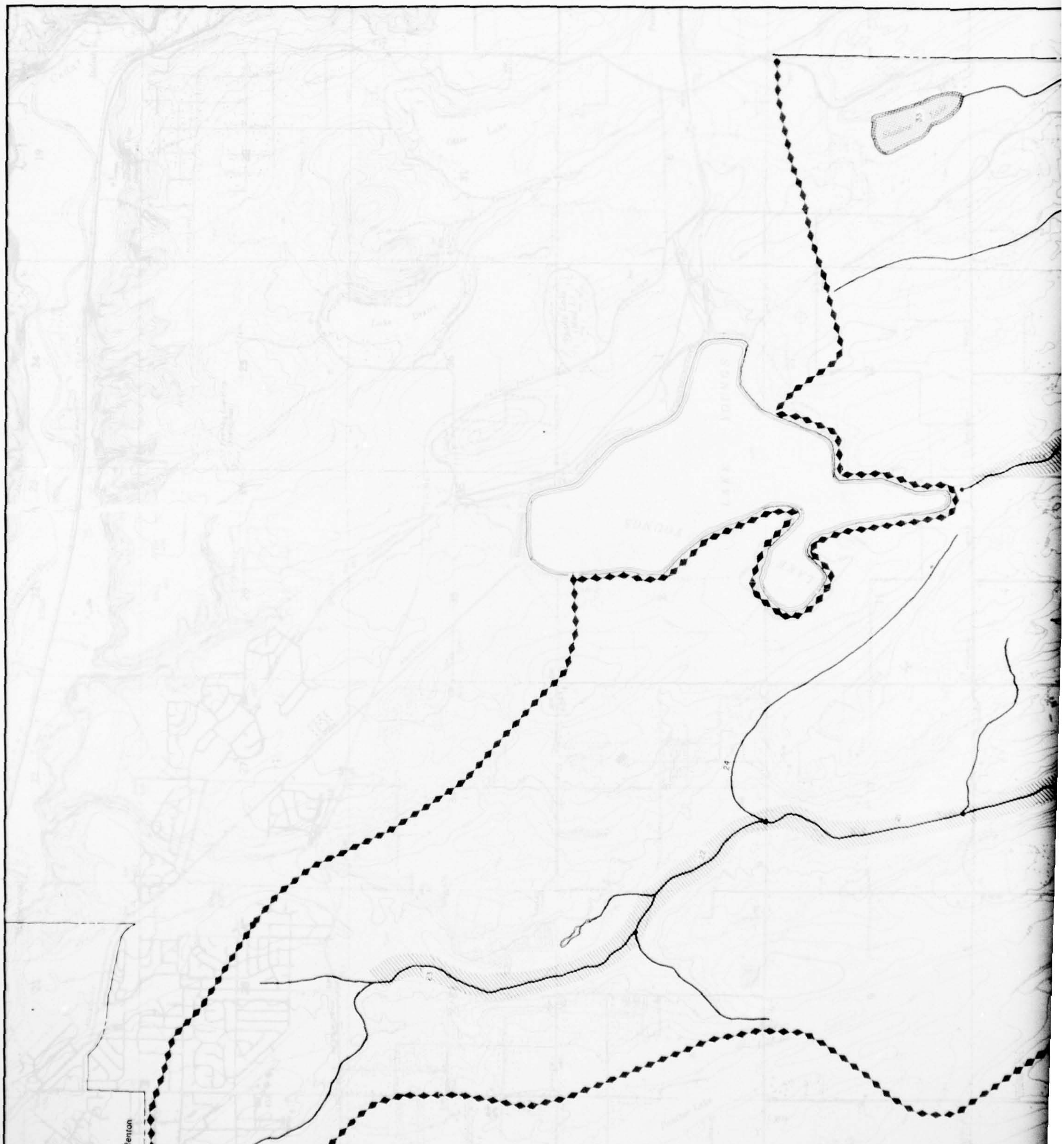
LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
	2000 Comprehensive Land Use						
Crisp Creek	I	80	0	1.2×10^3	0	.1	0
	II	40	0	1.2×10^3	0	.1	0
Coal Creek	I	220	0	1.2×10^3	0	.1	0
	II	150	0	1.2×10^3	0	.1	0
Deep Creek	I	110	0	1.2×10^3	0	.1	0
	II	60	0	1.2×10^3	0	.1	0

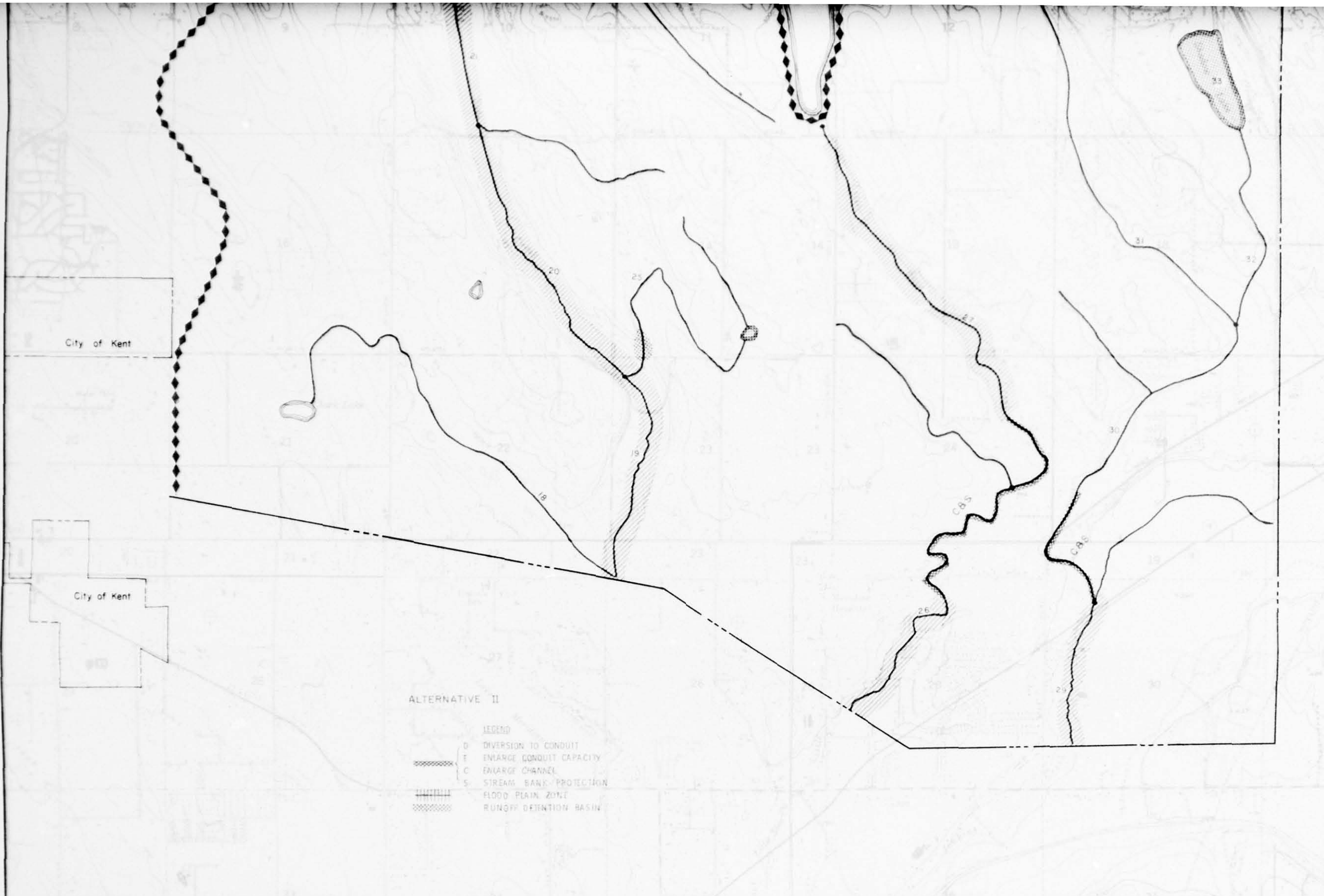
Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

MIDDLE GREEN RIVER

ALTERNATIVES	EFFECTIVENESS SUB TOTAL	Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	HUMAN VALUES SUB TOTAL	Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	ENVIRONMENTAL FACTORS SUB TOTAL	High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	IMPLEMENTATION SUB TOTAL	Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	RESOURCE REQUIREMENTS SUB TOTAL	Energy	Materials	Land	Capital	RATING TOTAL
CRITERIA WEIGHT		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	+14									+6								+4										-4							+4					+24
II	+24									+11								+34										-4							+10					+75


City of Renton



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

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MILES
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NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

BIG SOOS CREEK

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

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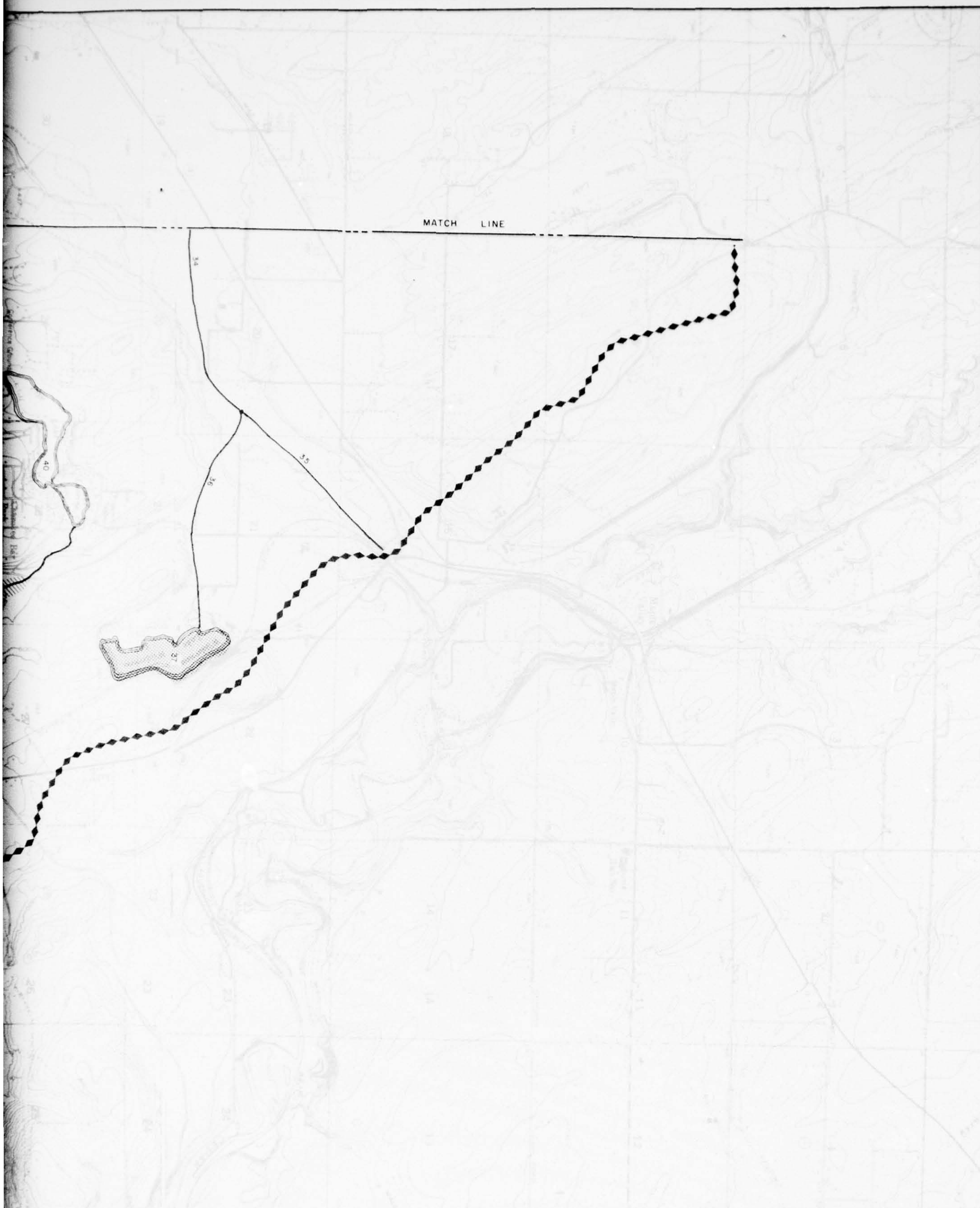
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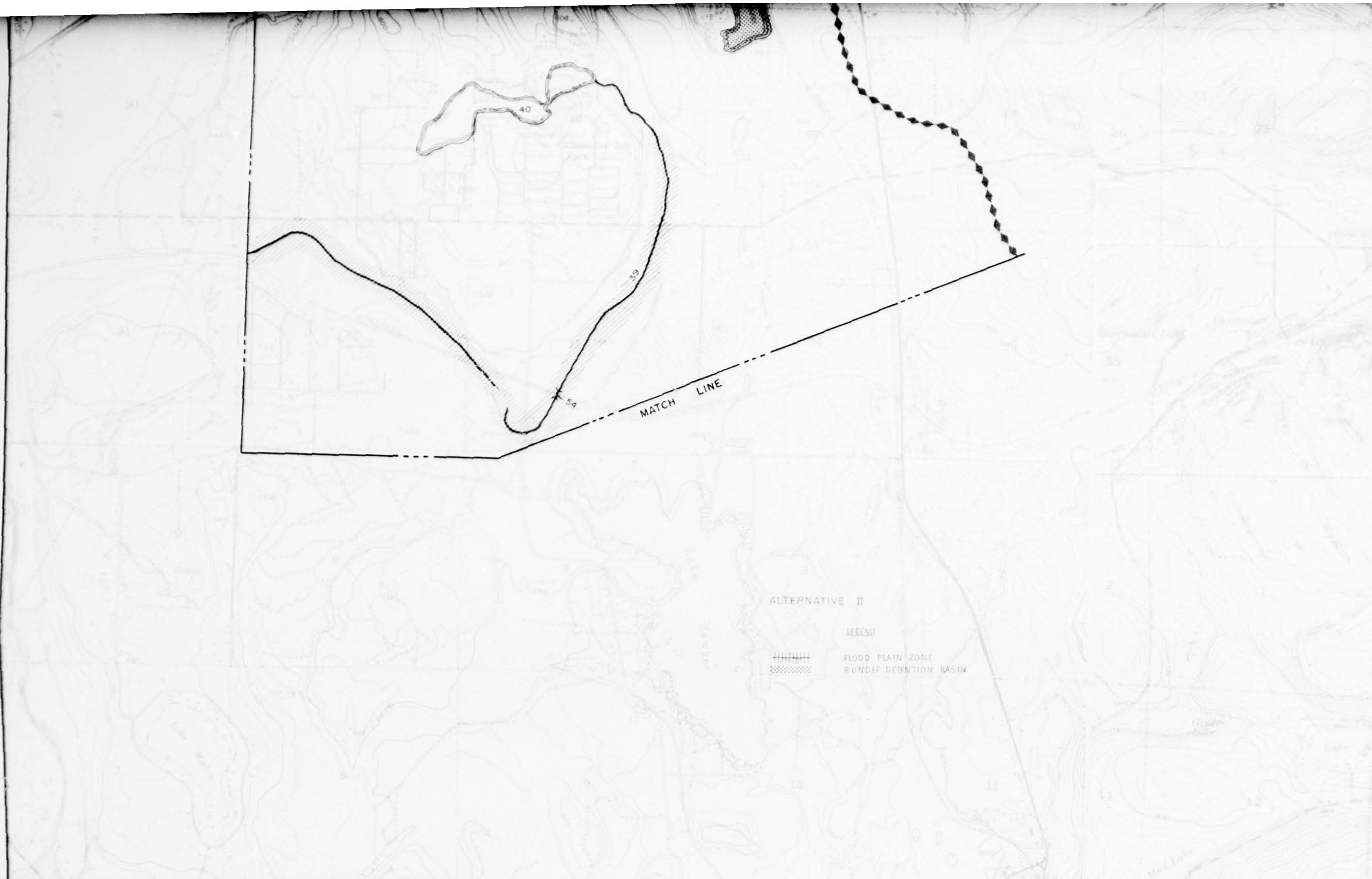

LEGEND

SUB-BASIN BOUNDARY
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MANHOLE, INLET, OR JUNCTION
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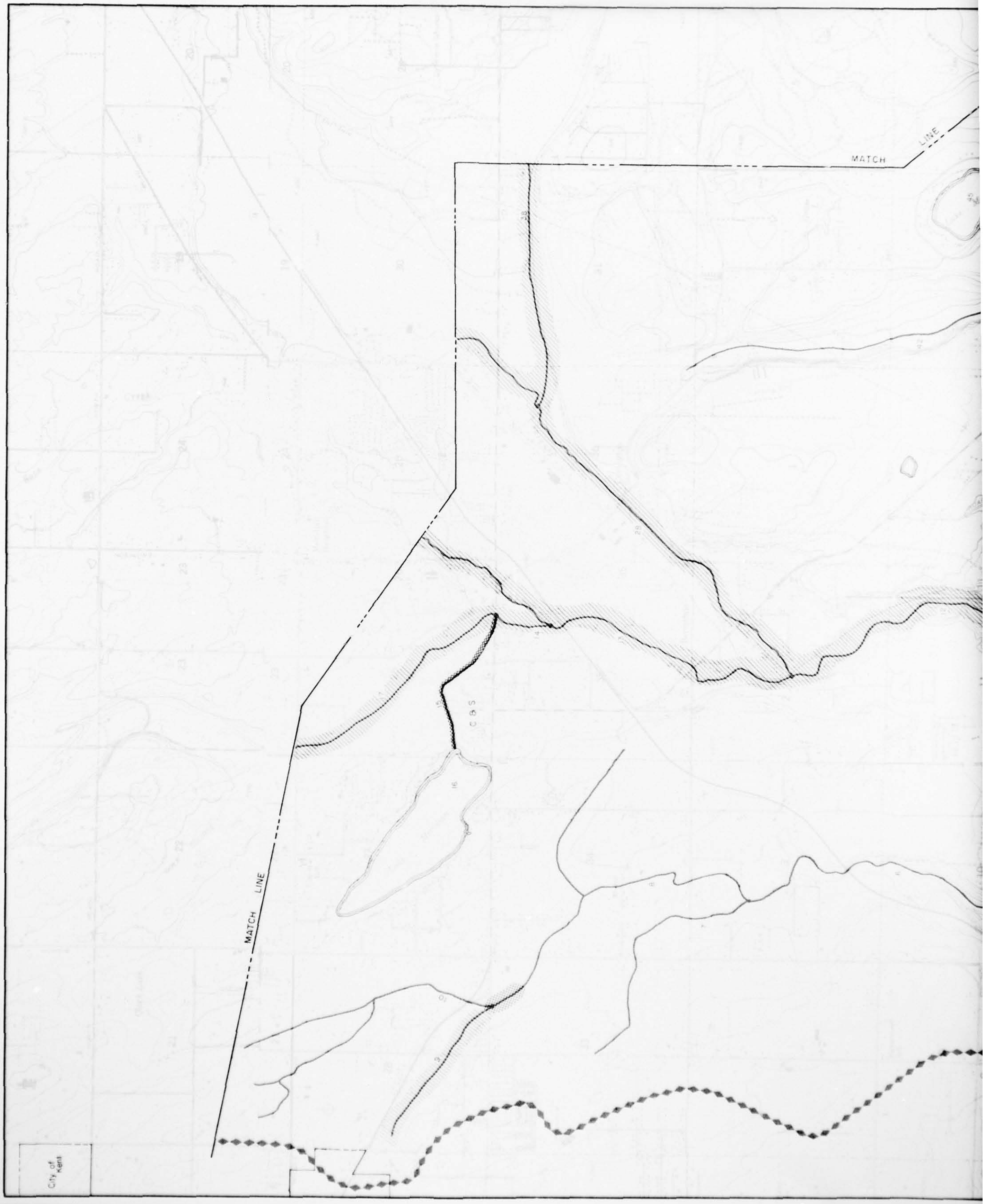
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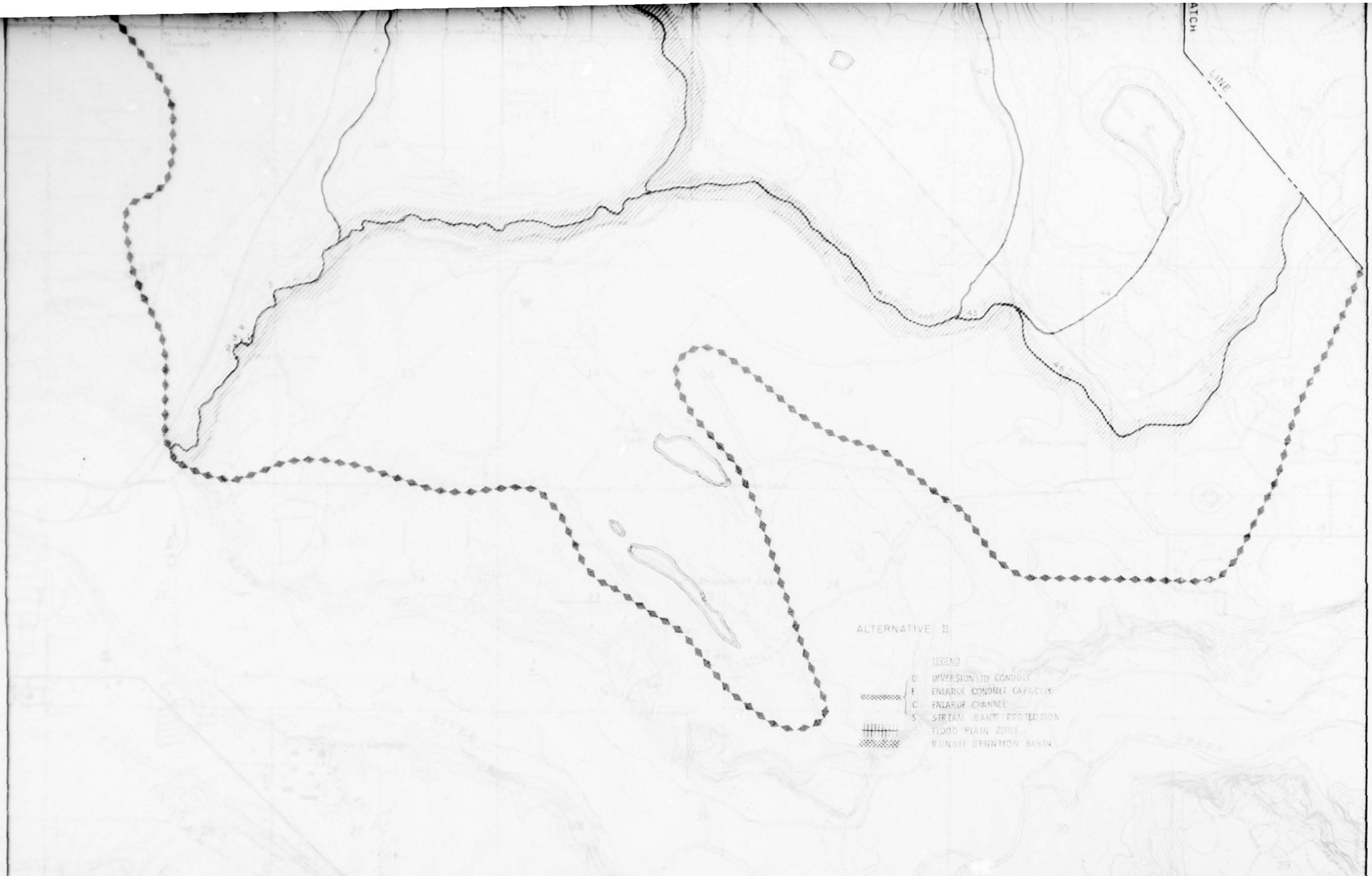

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ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)
DEC 74 DACW67-73-C-0022

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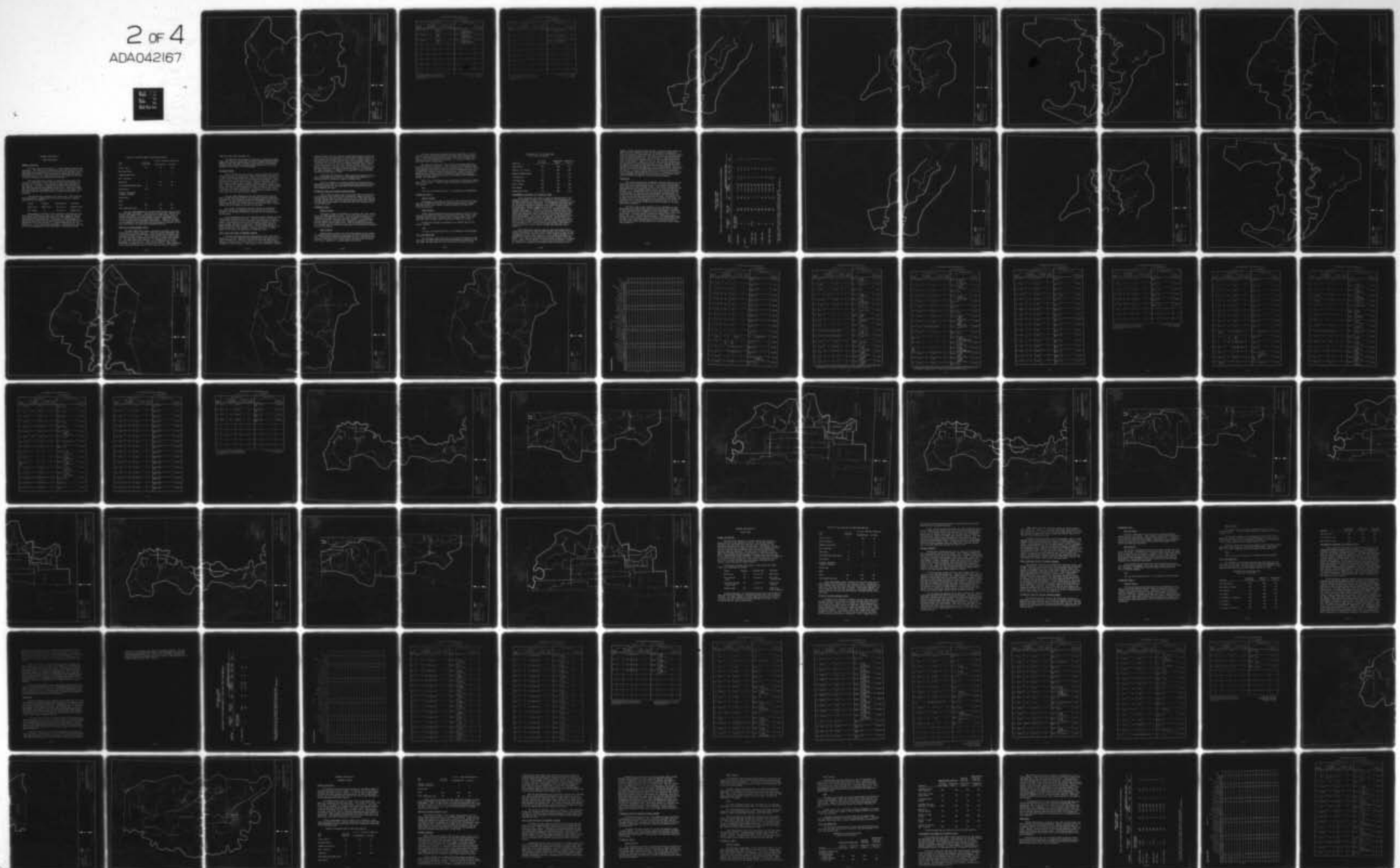

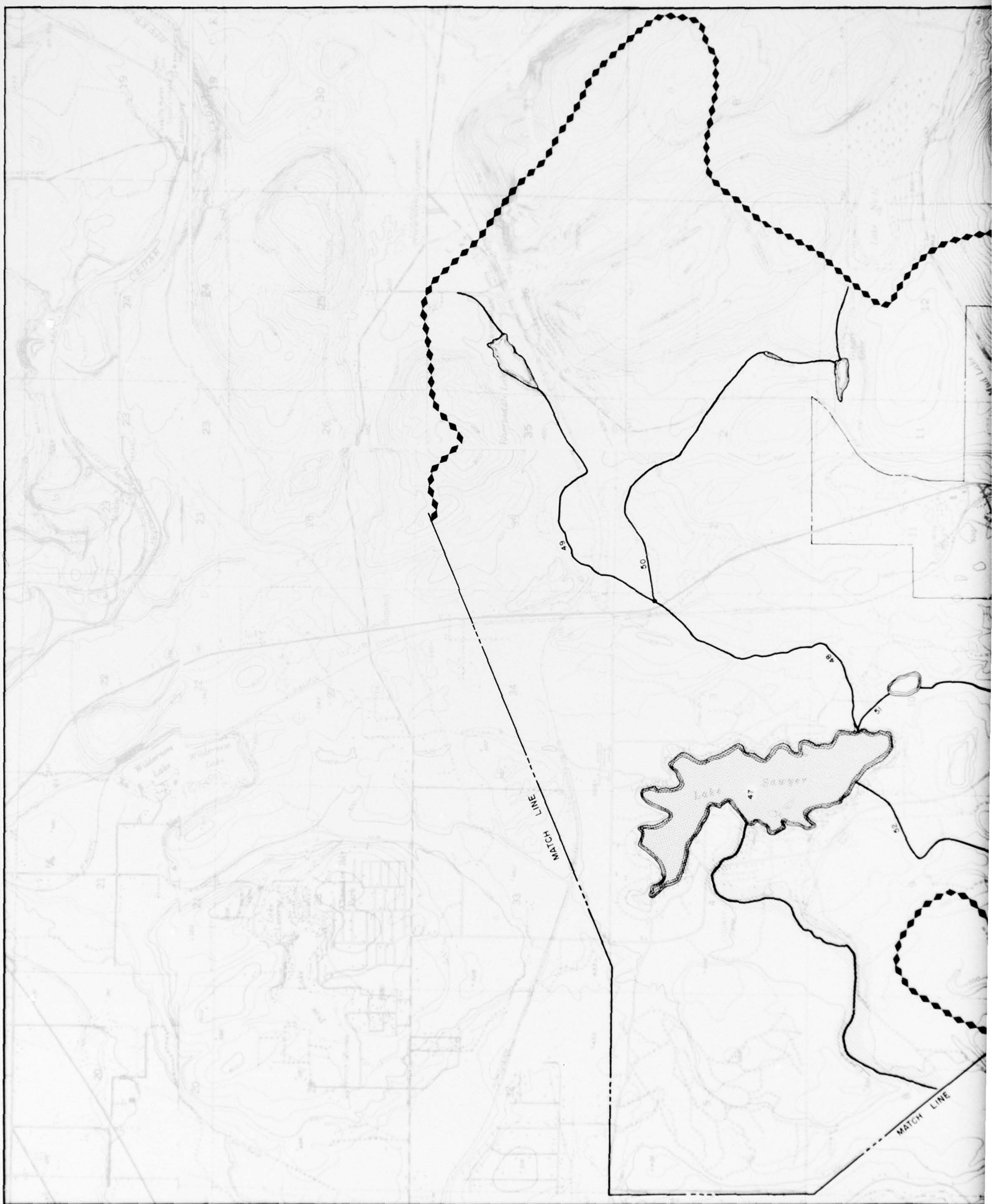
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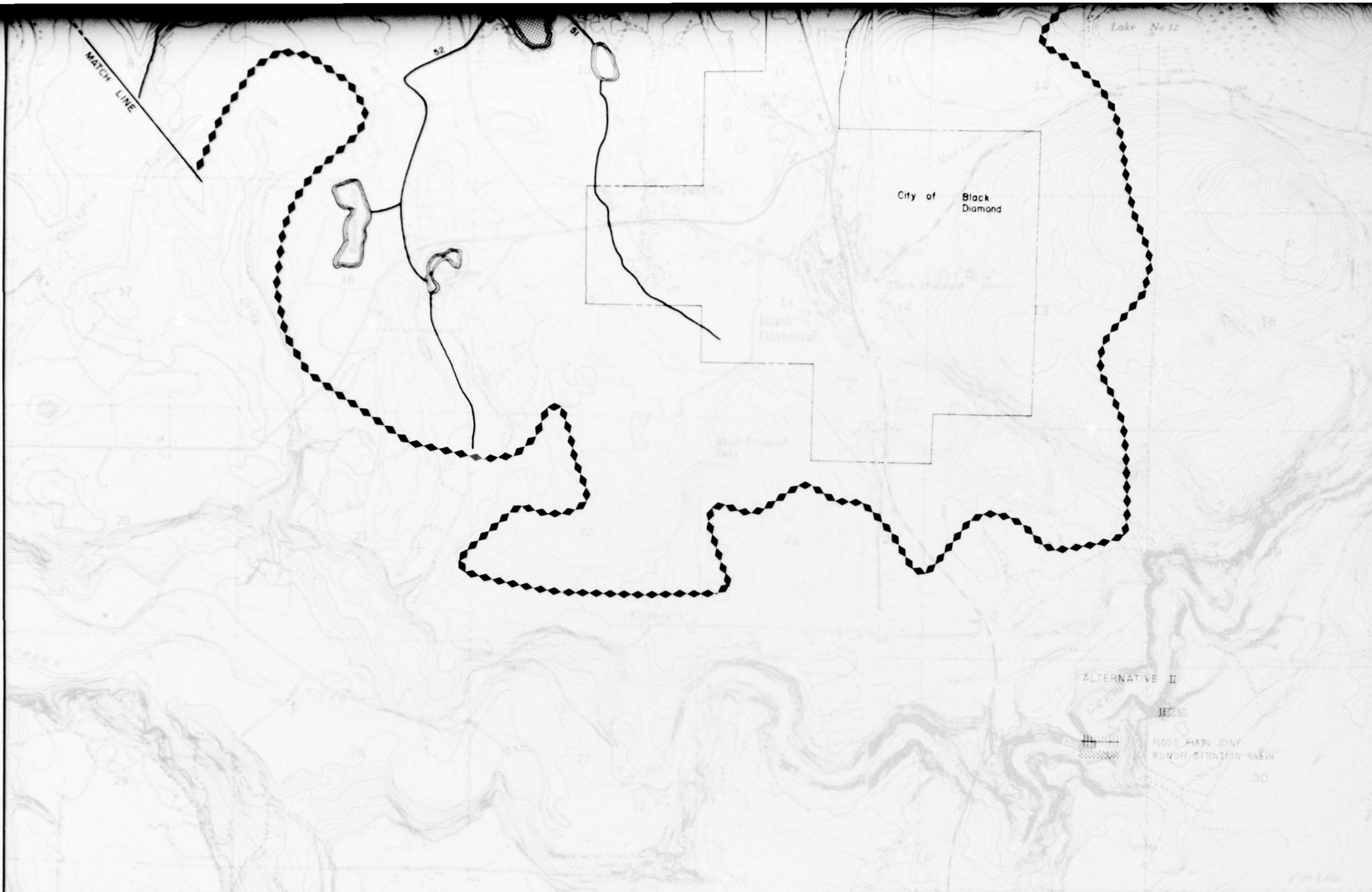

LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
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- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

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MILES: 1/2 1/4 0 1

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NO	DESCRIPTION	DATE	APPROVED

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RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Middle Green River

ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
22/23	Channel	8'	1,000' portion only	2:1	2'	Channel	10' width 2:1 side slopes 2.5' depth with 500' streambank protection	$20,000
42/43	Channel	8'	7,400' portion only	2:1	3'	Channel	12' width 2.1 side slopes 3' depth with 2,000' streambank protection	$50,000
53/54	Channel	8'	5,000' portion only	2:1	2'	Channel	10' width 2:1 side slopes 2' depth with 5,000' streambank protection	$60,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $130,000

Round To: $100,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

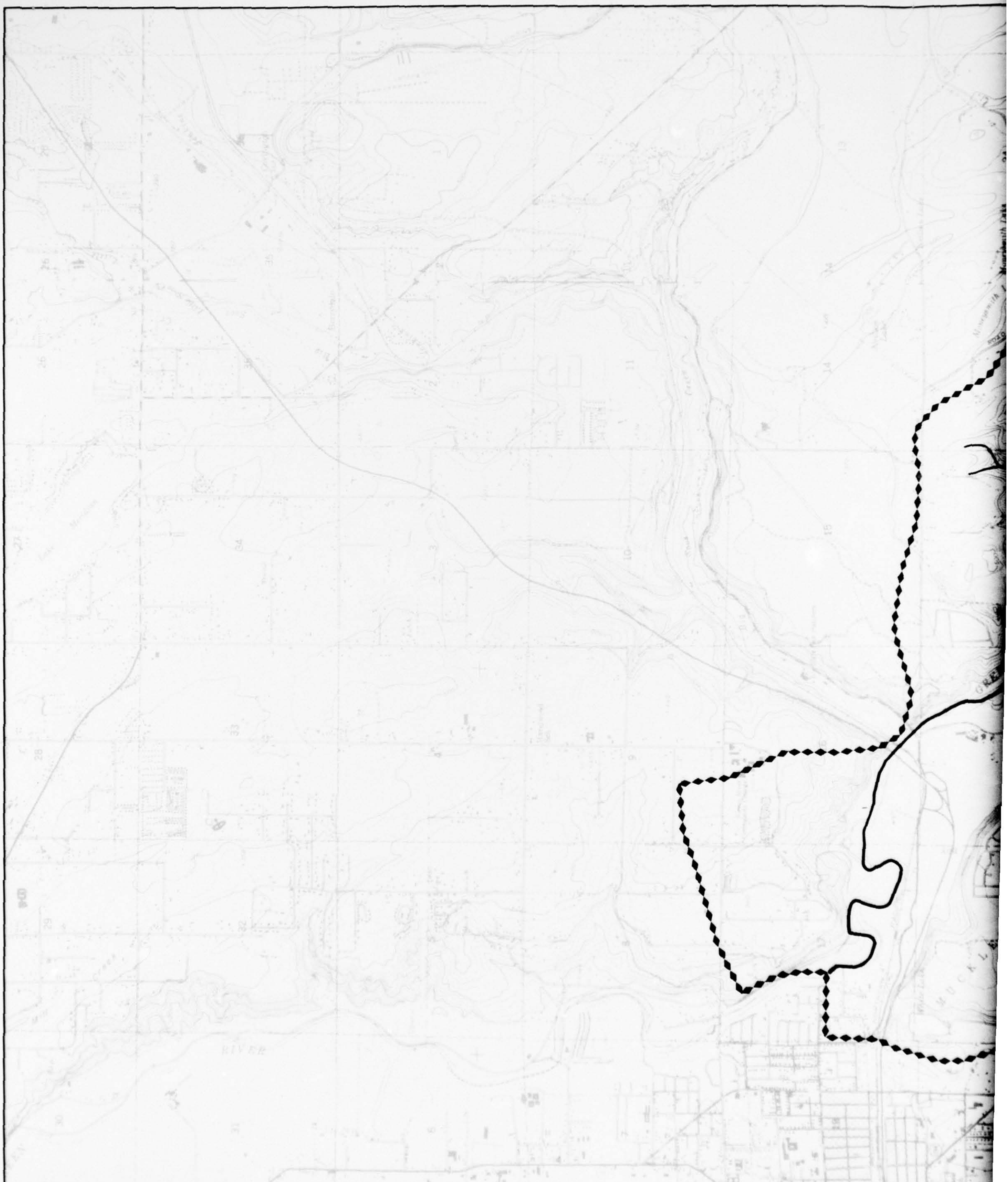
Alternative II Sub Basin Middle Green River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
23						Holding Pond	Modify existing pond to store 2.2 AF	$10,000
43						Holding Pond	6.7 AF storage east of railroad embankment	$40,000
54						Holding Pond	1.4 AF storage east of railroad embankment	$50,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $100,000

Round To: $100,000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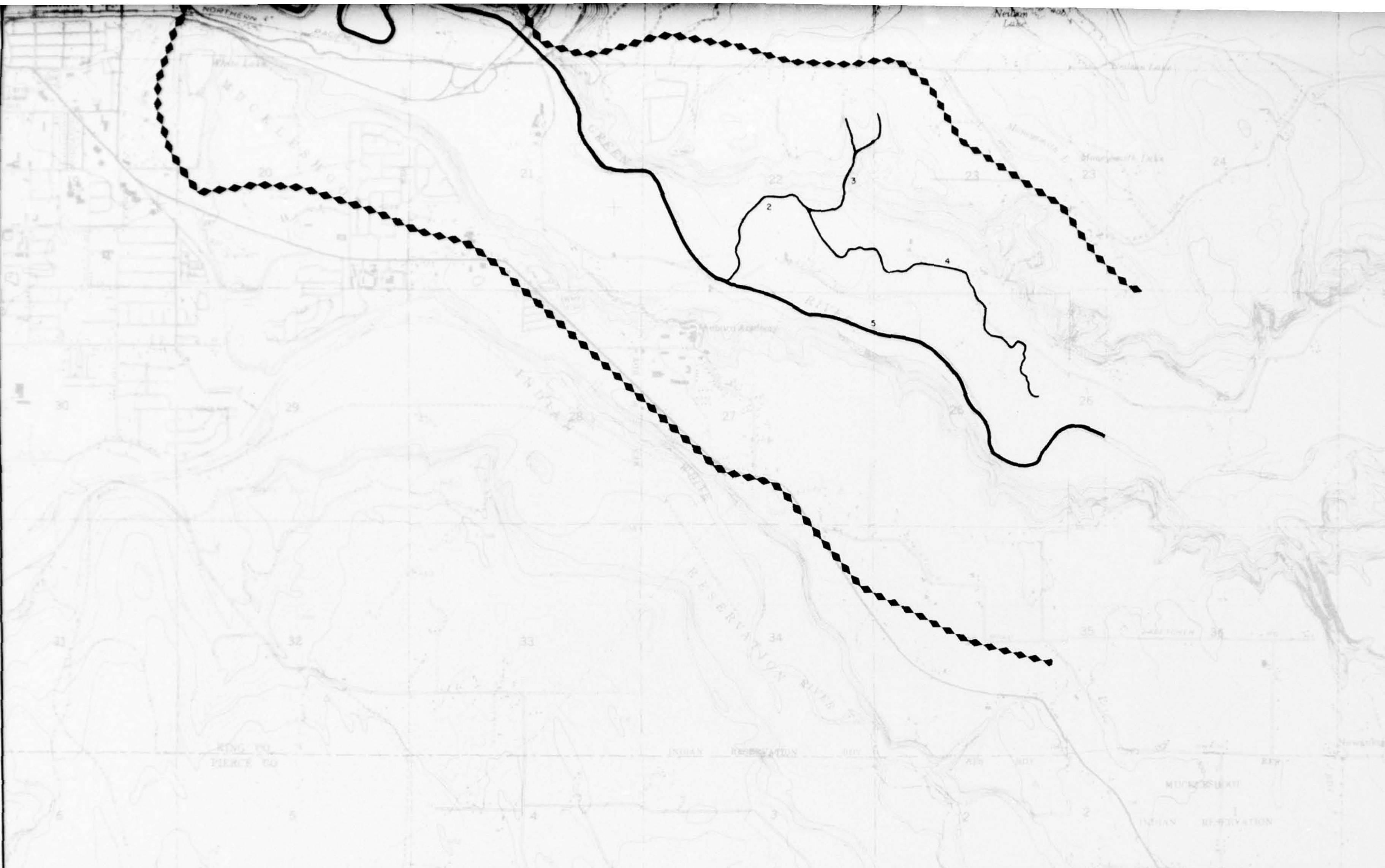

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COUNTY (METRO) BOUNDARY	
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NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MIDDLE GREEN RIVER

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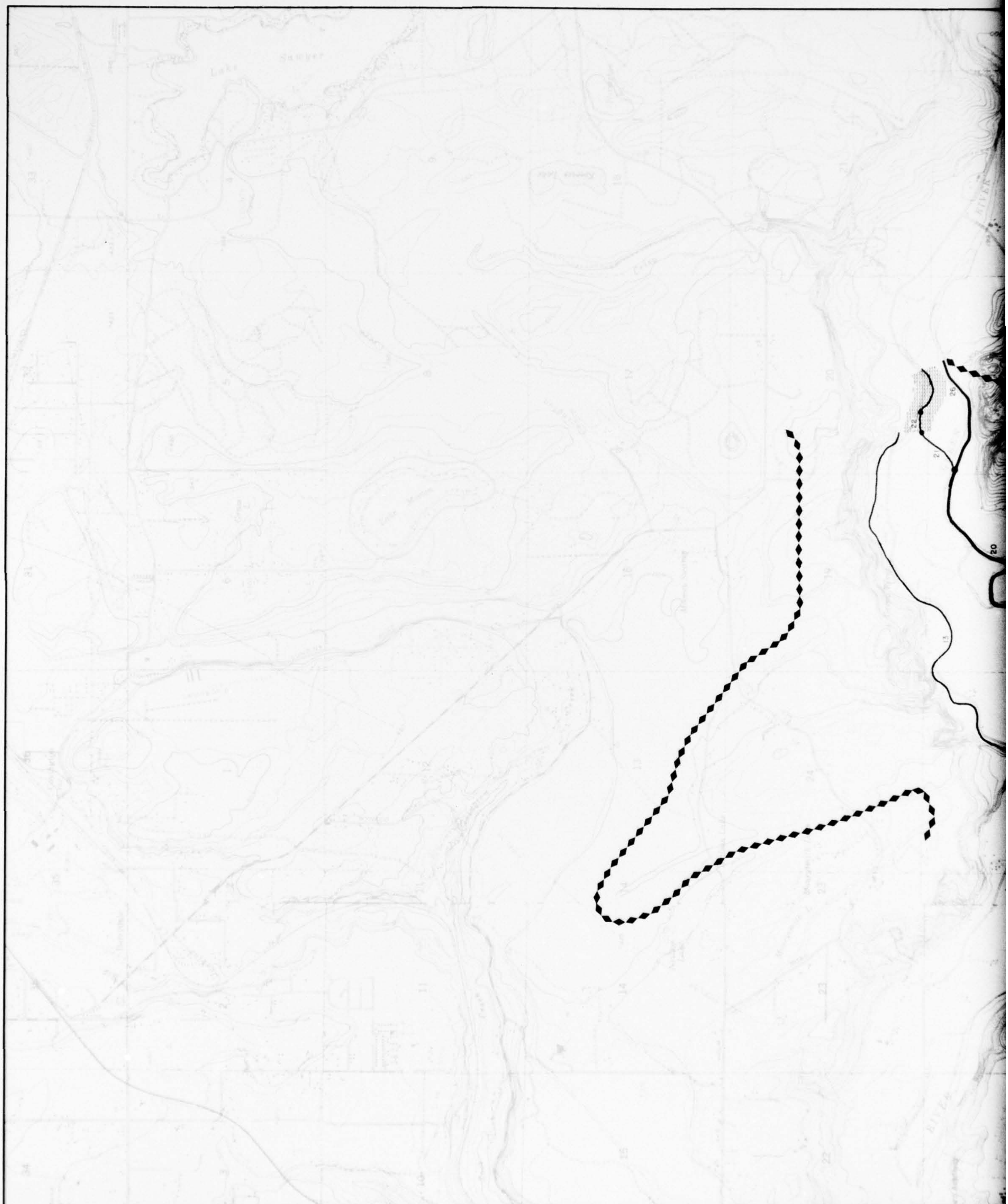

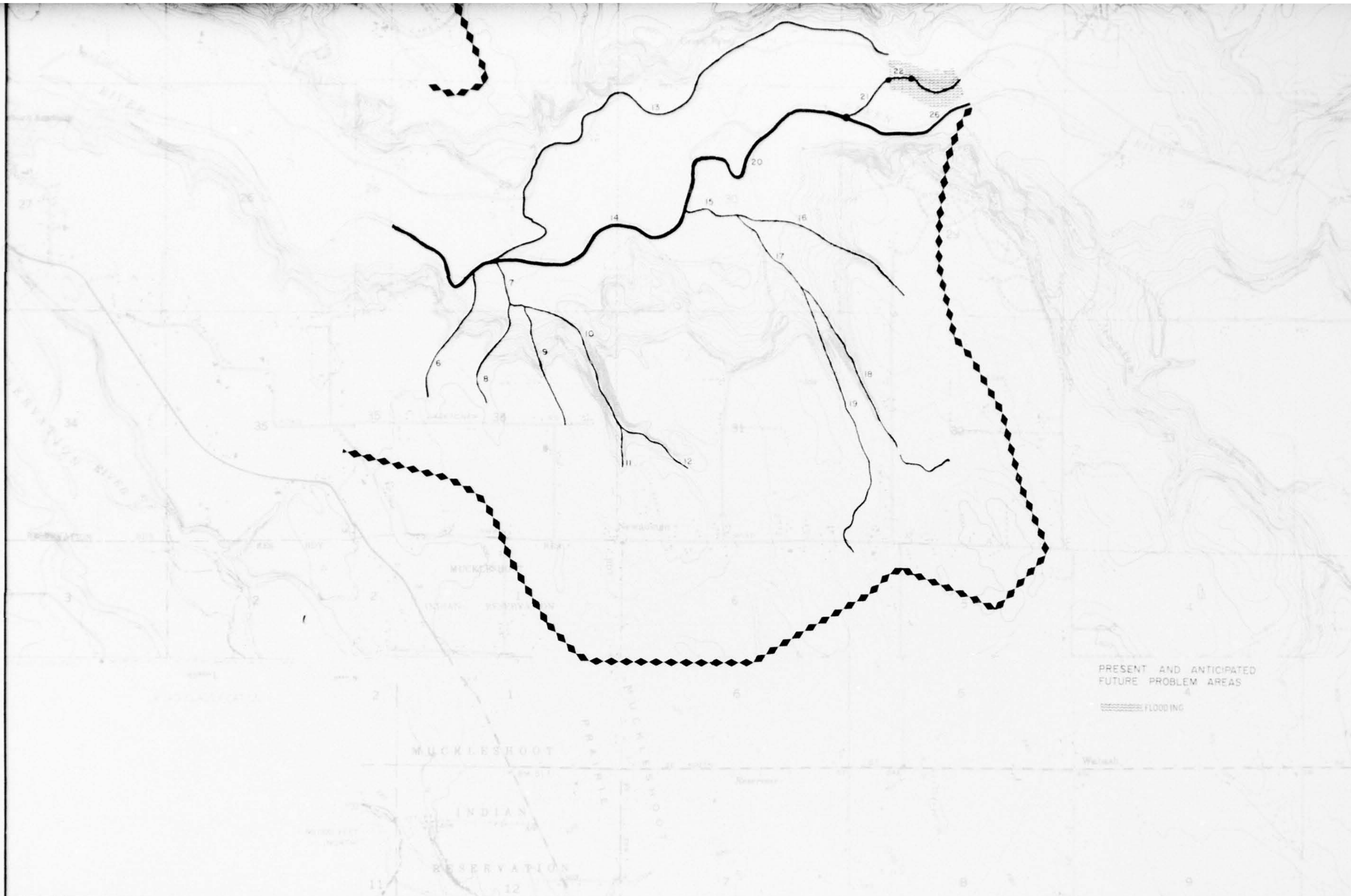

LEGEND

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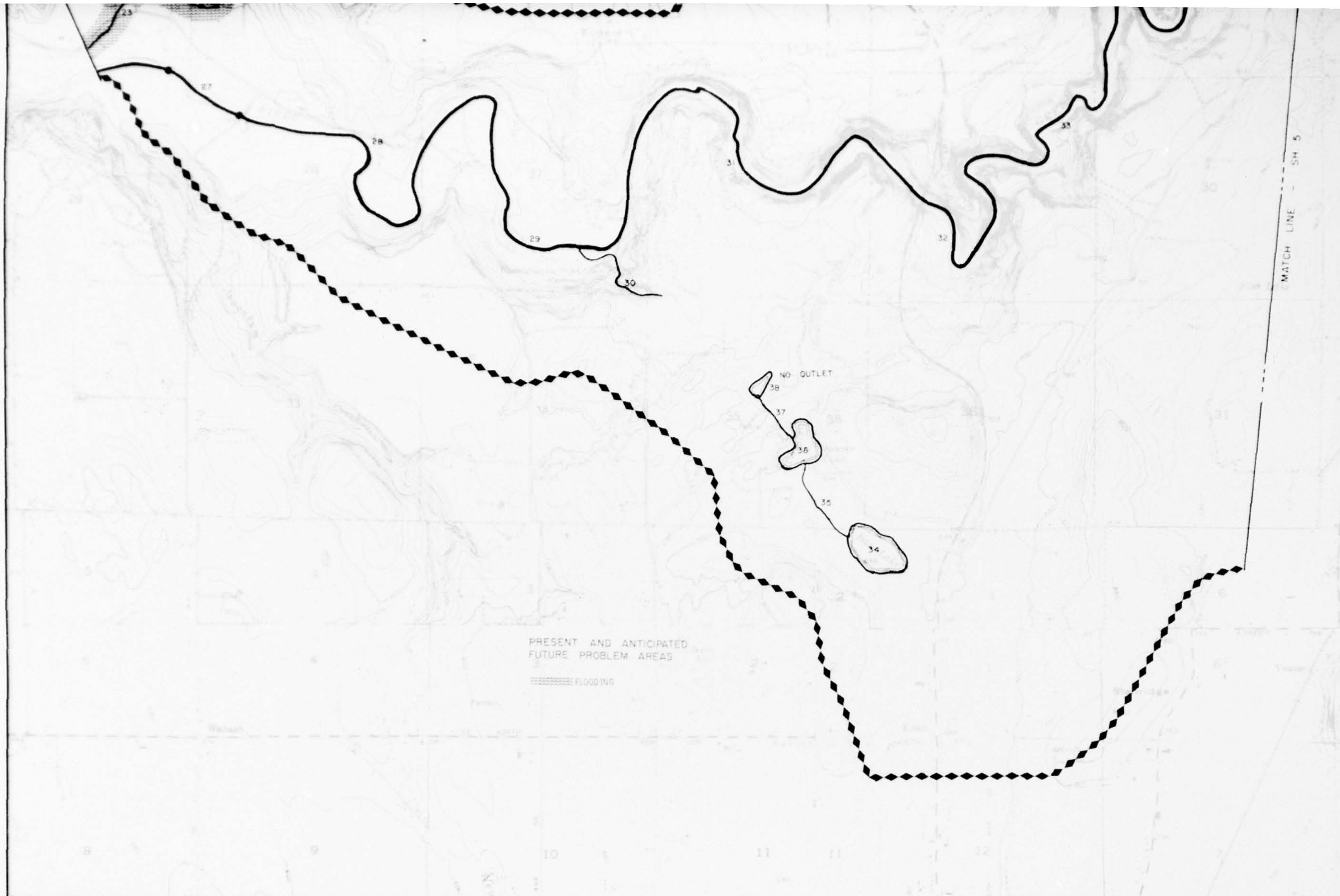

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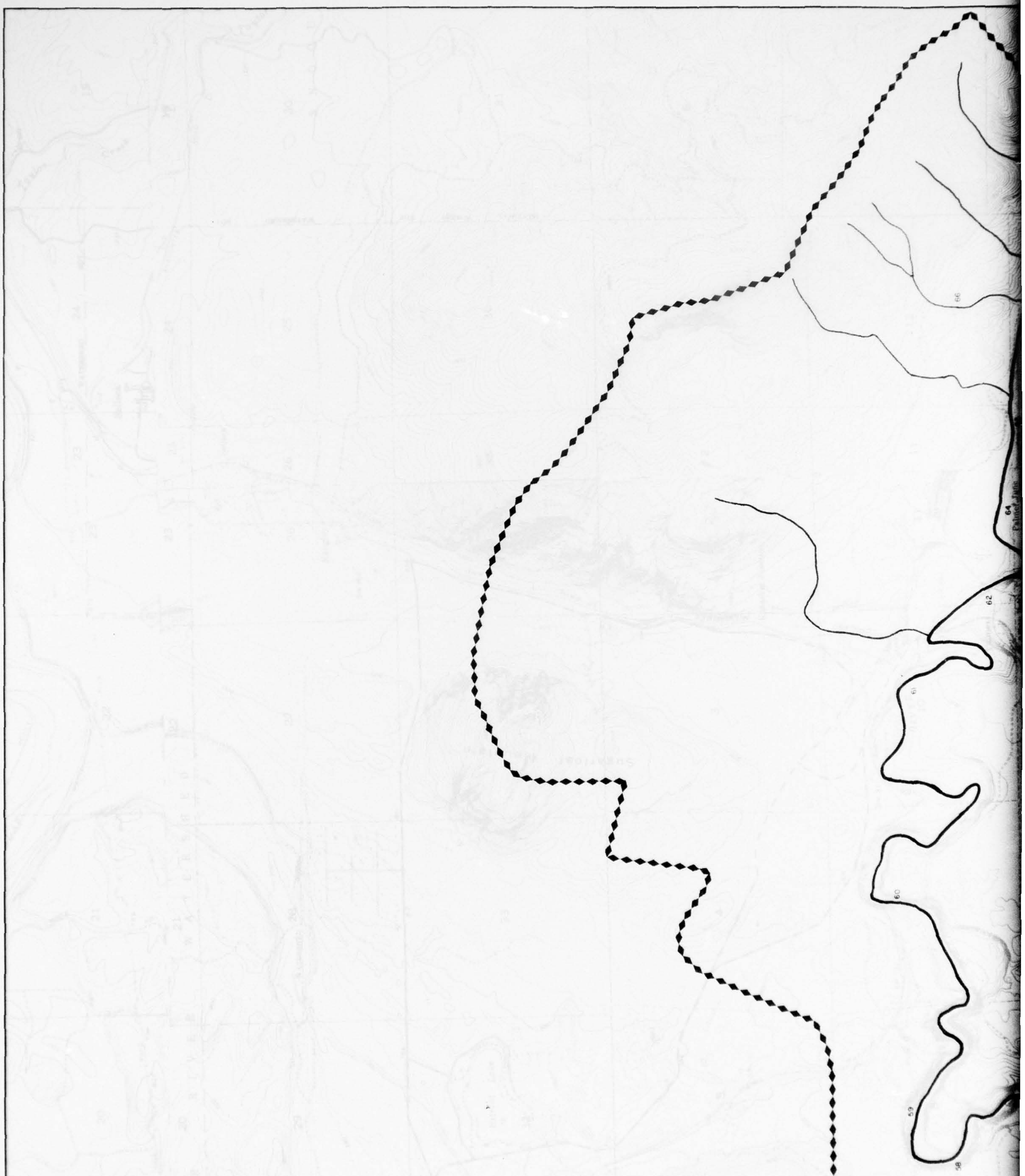
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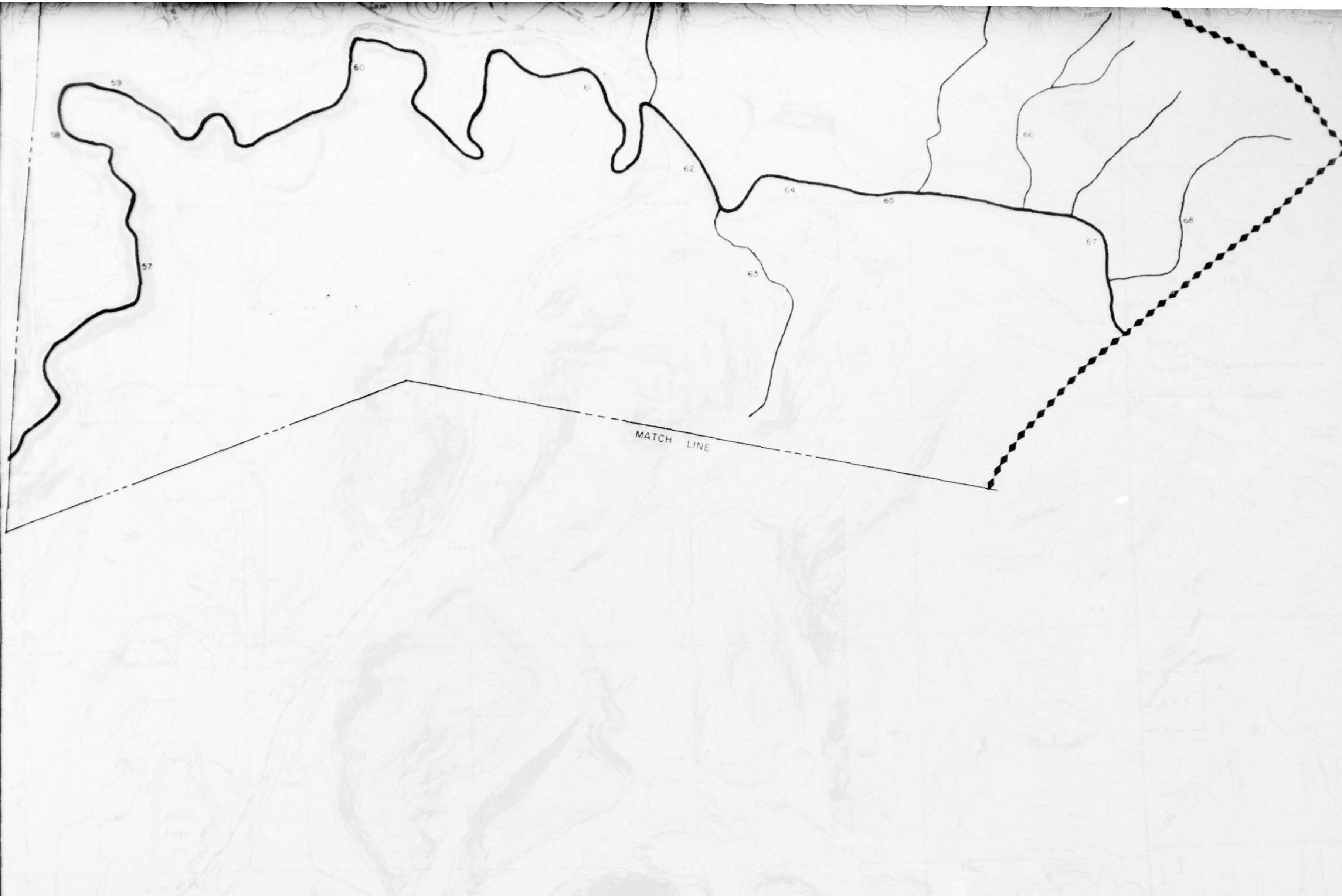

LEGEND

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- CITY LIMITS
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NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MIDDLE GREEN RIVER

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REGIONAL SUB-BASIN G-5

LOWER GREEN RIVER

GENERAL DESCRIPTION

The Lower Green River Sub-Basin is located between South Seattle and Auburn. This reach of the Green River flows from a point 1.8 miles downstream from the confluence of the Big Soos Creek and Green River to approximately the mouth of the Black River at Renton where it becomes the Duwamish River. Mill Creek, which drains the western third of the sub-basin, discharges to the Green River near Kent.

The Lower Green River Valley is a broad flat flood plain with steep hills bordering its west side and the Black River sub-basin on the east side. Terraces, lakes and marshy depressions characterize the uplands. The valley is composed of fertile alleuvial soils that have been deposited by the meandering Green River. Since agricultural and urban/industrial development have taken place in the valley, revetments and dikes have been constructed to maintain the existing river alignment.

The drainage basin consists of 36 square miles. Mill Creek has been designated as a demonstration area and has received a separate evaluation in this Appendix.

Stream	Category	Drainage Area	Discharge
Green River	Major River	23.0 sq. mi.	Duwamish River
Mill Creek	II	13.0 sq. mi.	Green River

Approximately 40 percent of the sub-basin is utilized for vegetable and berry production, beef, dairy and other commercial farming. The trend has been to industrialization since the completion of the Howard Hanson flood-control dam. The changes in land use began with the Boeing Space Center and are typified by Andover Industrial Park and Southcenter in the City of Tukwila. A large percentage of the residential use is rural low-density development. These and other land uses are shown as percentages of total land area in the following table.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	50	64	64
Multiple Family		2	2
Commercial/Services	1	3	3
Govt. and Educ.			
Industrial	1	20	20
Parks/Dedicated Open Space	2	10	10
Agriculture	40		
Airports, Railroads, Freeways, Highways	1	1	1
Unused Land	5		
Water			
Total	100	100	100
Total Impervious Area	15	45	45

The year 2000 Comprehensive and year 2000 Corridor land-use plans have negligible differences. Future land-use projections indicate that industry and commerce will occupy nearly all of the central valley or existing flood plain, and that suburban residential development will increase in the uplands and around urban centers. Commercial farming, in all likelihood, will be completely eliminated. The plans for intensive development of the Green River Valley have been the subject of much public and official criticism and considerable conflict.

NATURE OF EXISTING DRAINAGE SYSTEM

The Lower Green River system is primarily a pastoral river with sinuous natural tributary channels. Urban and upland developments have incorporated standard closed-conduit storm systems that discharge into the nearest natural channel. Within the Green and Black river systems, there are 2700 acres of wetlands and 700 acres of brushy wildlife habitat. The Lower Green River primarily is a floodway and a principal passageway for migrating fish. Major chinook spawning areas on the Green River are above Auburn in the small tributaries. Some tributaries to the Lower Green River, such as Mill Creek, are important spawning

areas for coho salmon and game fish.

The industrial and commercial businesses in Tukwila have developed storm drainage systems that rely upon a pumped drainage outlet. Because of the high water profiles of the Green River and prevalent flooding within the valley, pumped drainage appears to be the only solution if the valley is to be developed.

DRAINAGE PROBLEMS

Major problems have been noted by county and municipal agencies. Extensive flooding of agricultural lands including about 10,500 acres in the Black and Lower Green River systems occurs during high flood stages. Losses of seed and crops and extensive road damage is caused by prolonged inundation during floods. Seasonal high-water table in the flood plain due to poor subsurface drainage reduces crop production. Erosion and sloughing of mainstream and tributary channel embankments, mudslides on steep unprotected slopes, washout of storm drainage structures, and debris accumulation in channels and culvert inlets cause extensive local flooding while sedimentation in streams and the river poses a serious water quality problem.

The year 2000 Comprehensive and year 2000 Corridor Land Use Plans for the basin are identical and designate extensive industrial development in the valley and residential development on the hillside plateaus. The total impervious area in this sub-basin under either land-use projection will increase from an existing 15% level to approximately 45% as indicated by the table of land uses.

The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Land Use Plans. Therefore, the drainage alternatives presented herein are applicable to both plans.

Open, unprotected areas will experience greater flooding problems without proper drainage facilities. Hillside streams will receive a several-fold increase in runoff, and severe gully erosion can be anticipated if the present policy of utilizing natural streams for urban storm drainage collectors is continued. Storm-drainage systems in Auburn already are under-designed for the 10-year storm and nearly all systems would need to be replaced. Likewise, nearly all drainage canals in the valley are undersized for expected runoff.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

The West Side Green-Duwamish Watershed Work Plan, under Public Law No. 566, has been adopted as the comprehensive drainage plan by its sponsoring agencies. Funds for construction have been authorized by Congress but construction cannot begin until the Environmental Impact Statement has been approved. King County currently reviews all proposed

drainage projects that are related to development projects within the valley, and the State Department of Ecology has ultimate authority to grant permits for drainage construction. By this system of permit, it has been possible for the County to insure that drainage channels and structures are consistent with the proposed watershed plan. Sponsors of the watershed plan are the cities of Kent, Renton, Tukwila, and Auburn, King County, the Green River Flood Control Zone District, and the King County Soil and Water Conservation District. An Environmental Impact Statement is scheduled to be completed in early 1974 and construction could begin in 1975.

King County and Tukwila are requesting advance approval to construct a pump station and canals to give immediate protection to a 200-million dollar industrial complex at Andover Park.

The City of Auburn is currently conducting a storm drainage improvement study which will be contingent upon the selection of alternative systems for both the Lower Green River Sub-Basin and the Mill Creek Demonstration Area.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Lower Green River Sub-Basin as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

The present trend of development is assumed to the level indicated by the 2000 Comprehensive Plan. No on-site runoff control is considered and drainage facilities are sized to prevent all potential flooding and erosion along main collector channels. Valley drainage would be pumped into the Green River. Generally, channels will be enlarged and hillside streams will be lined to prevent gully erosion. It is assumed that all upland drainage would be collected and discharged into hillside channels.

Major Features

Pumped drainage systems are a principal element in this scheme. The pumped drainage systems as projected by the Soil Conservation Service in the Westside Green River Watershed Plan are utilized with modification to exclude the Mill Creek area of the Lower Green Sub-Basin. Mill Creek is modeled as a separate demonstration area.

Hillside streams are lined with rip-rap or concrete in critical sections where expected flows exceed flow rates under existing conditions. Intercepting storm-drain collector pipes are used where county road right-of-ways have been established or in ravines in which construction would be accomplished.

Municipal and industrial systems would be enlarged where necessary with parallel storm drains. The P-17 system of the Westside Green River Watershed Plan deserves special attention because it must be built to accommodate runoff from an existing industrial park that relies upon an undersized, temporary pumped drainage system. Runoff entering the pumped drainage system has been substantially reduced by a pressure hillside drainage interceptor that was constructed by the Department of Highways and King County.

Nearly all of the capacities of storm drains in the City of Auburn need to be increased. Parallel conduits would be most appropriate for this purpose.

Cost

The cost for Alternative Plan I is estimated to be $10,800,000.

ALTERNATIVE PLAN II

General Concept

Development of drainage facilities for this alternative is based upon the assumption that an on-site runoff control policy is adopted which would limit the increase in peak discharge to 25% more than existing conditions.

Major Features

Valley pumped drainage and hillside systems are similar to those discussed in Alternative Plan I, but generally are less costly. Holding ponds would be used in upland areas to retard runoff. Diversion pipes are used to reduce runoff into natural streams in ravines.

Forebay pond storage is developed as an integral part of the channel systems.

Cost

The cost for Alternative Plan II is estimated to be $9,300,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows under existing facilities and under alternative drainage management solutions for the year 2000. The peak flows are given for various locations as noted.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
South Center	220	500	420
Tukwila, P-17 System	210	430	280
Andover Highway Bypass	70	120	110
P-6 Pump Site	60	160	160
P-24 Pump Site	N/A	50	45
Mullen Slough	350	770	560
83rd Avenue	N/A	300	190
Auburn Main Street	40	300	250

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternative plans for this sub-basin. This procedure was followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs the pumped systems, new channels, channel lining and diversion, was a minus 49 on a scale ranging from a possible positive total of 108 to a negative total of 108. The total evaluation rating for Alternative Plan II, which employs pump stations, new channels, channel protection, runoff control, storage and diversion, was a minus 37.

Both alternatives received negative rating for effectiveness, primarily because of the need for pump stations, the difficulty in maintaining such systems, the difficulty in changing these systems and the consequences of over-charge especially in the valley area where it is assumed that industrial and commercial uses would front on the Green River . Also, the cost/benefit ranking of both alternatives is extremely low except to those who may own properties which could be utilized for industrial or commercial development after installation of the

system. Neither alternative was superior in terms of human values and both were given negative ratings for environmental considerations, primarily because of their potential for disruption of wildlife, aquatic life and marshland vegetation. The period of construction disruption would be rather extensive for either alternative. Both alternatives also received equally negative ratings in both implementation and resource requirements. Except for the fact that the Soil Conservation Service portion of the alternative plans has been approved and funded, the remaining systems for the upland areas require funding and joint agreement by the affected agencies prior to implementation. Both alternatives are believed to be extremely consumptive of natural resources and capital. The use of runoff control as a premise for Alternative Plan II requires smaller man-made facilities, but because of the extensive development anticipated in the sub-basin, runoff control alone cannot alleviate the need for extensive man-made systems.

CONCLUSIONS

The systems necessary to accommodate projected land use for the Lower Green River involve major sacrifices in terms of both environmental factors and general human values. There would be some benefit from Alternative Plan II because of the runoff control provided in new development and the attendent lower costs of the necessary man-made systems. It is assumed that the Soil Conservation Service Plan will be implemented in a form near that now proposed, and therefore, the portion of the Alternative Plan presented that requires coordination is that dealing with the upland and hillside areas. King County, City of Auburn and City of Tukwila should move to implement and enforce the necessary runoff controls suggested in Alternative Plan II if this alternative is to be part of the runoff control system for the Lower Green River Sub-Basin.

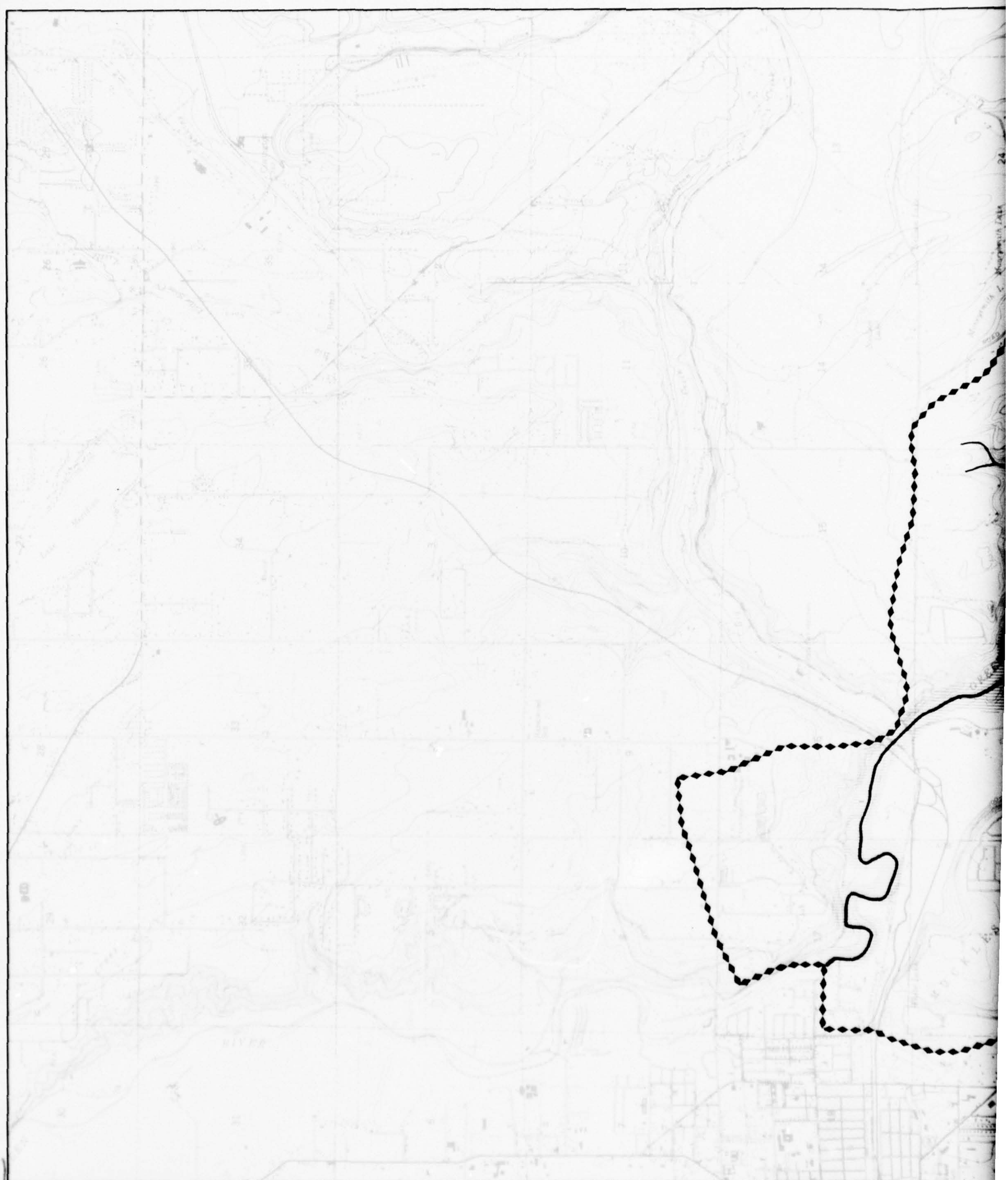
The basic issue in this sub-basin is the commitment to total development of the Lower Green River flood plain and the environmental and monetary costs of accomplishing this development. There also is the issue of the use or extent of use of runoff control from future development. This will require coordination between the City of Auburn, the City of Tukwila and King County. King County should have responsibility for overall control of drainage and flood damage within the Lower Green River Sub-Basin,and the City of Auburn and City of Tukwila should control new development and zoning within their respective boundaries.

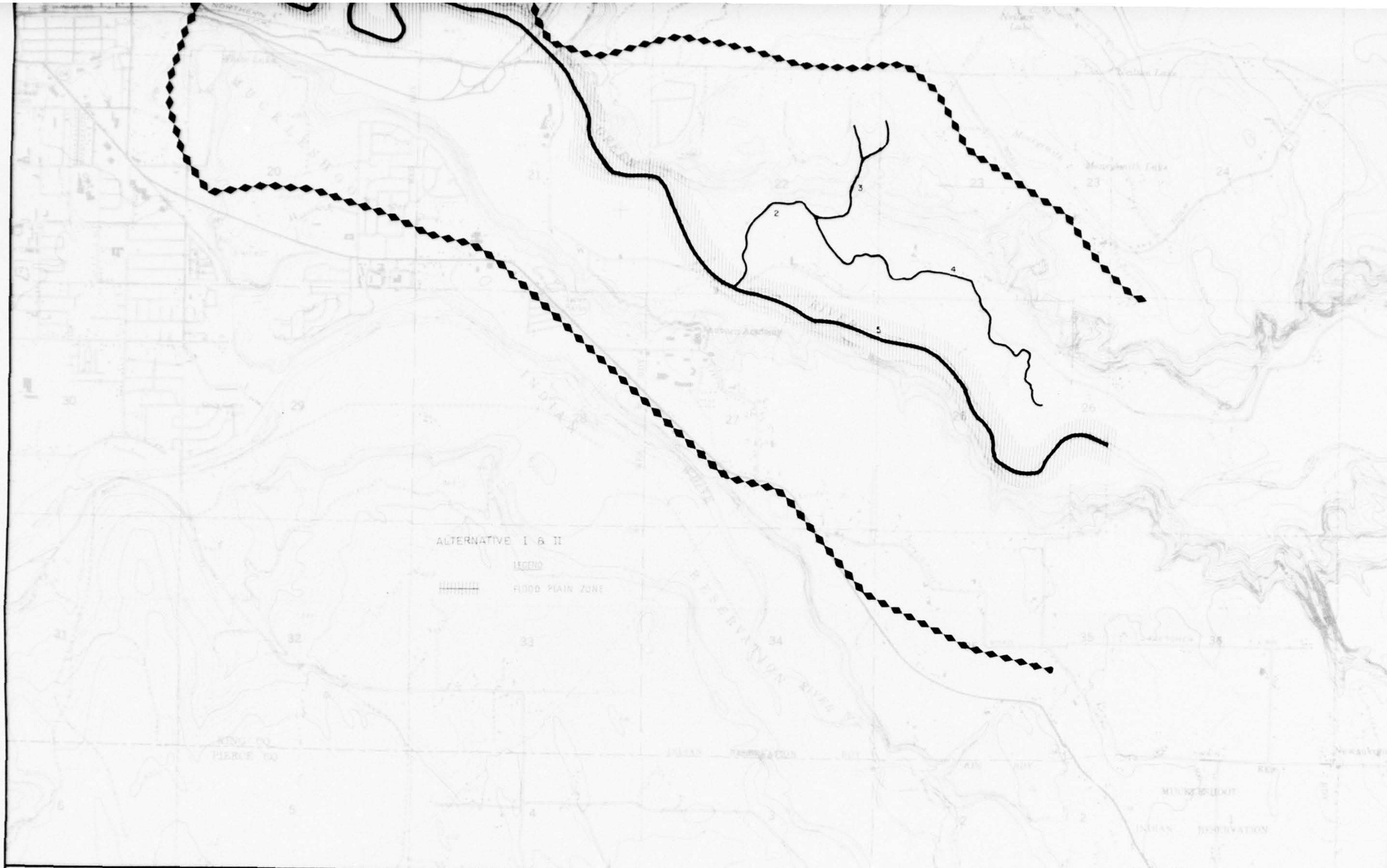
RUNOFF QUALITY SUMMARY
LOWER GREEN RIVER

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
	2000 Comprehensive Land Use						
Southcenter	I	580	24	1.1×10^6	1.1	2.1	.2
	II	490	26	1.1×10^6	1.2	2.3	.2
Tukwila	I	430	10	0.5×10^5	.4	1.2	.1
	II	280	13	0.6×10^5	.6	1.7	.2
P-6 Pump Site	I & II	160	1	4.7×10^3	0	.6	0
P-4 Pump Site	I	710	6	1.2×10^5	.1	.4	0
	II	560	7	1.3×10^5	.1	.5	0
P-7 Pump Site	I	300	12	4.7×10^4	.5	1.1	.1
	II	190	15	0.6×10^5	.6	1.5	.1
Auburn Main Street	I	300	31	0.8×10^6	1.2	2.3	.2
	II	250	32	0.9×10^6	1.2	1.7	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.





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MANHOLE, INLET, OR JUNCTION
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NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MIDDLE GREEN RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

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SEATTLE, WASHINGTON

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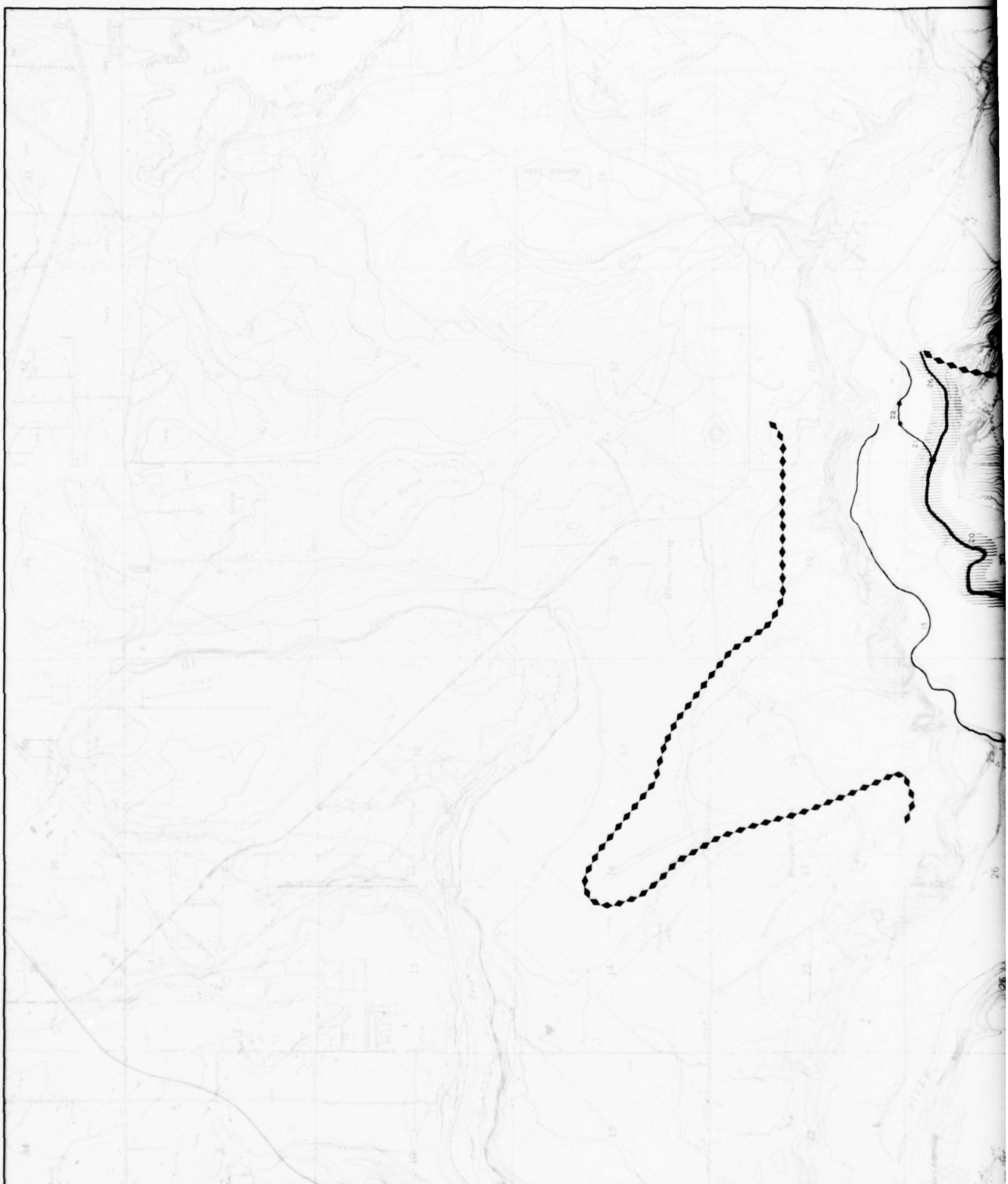

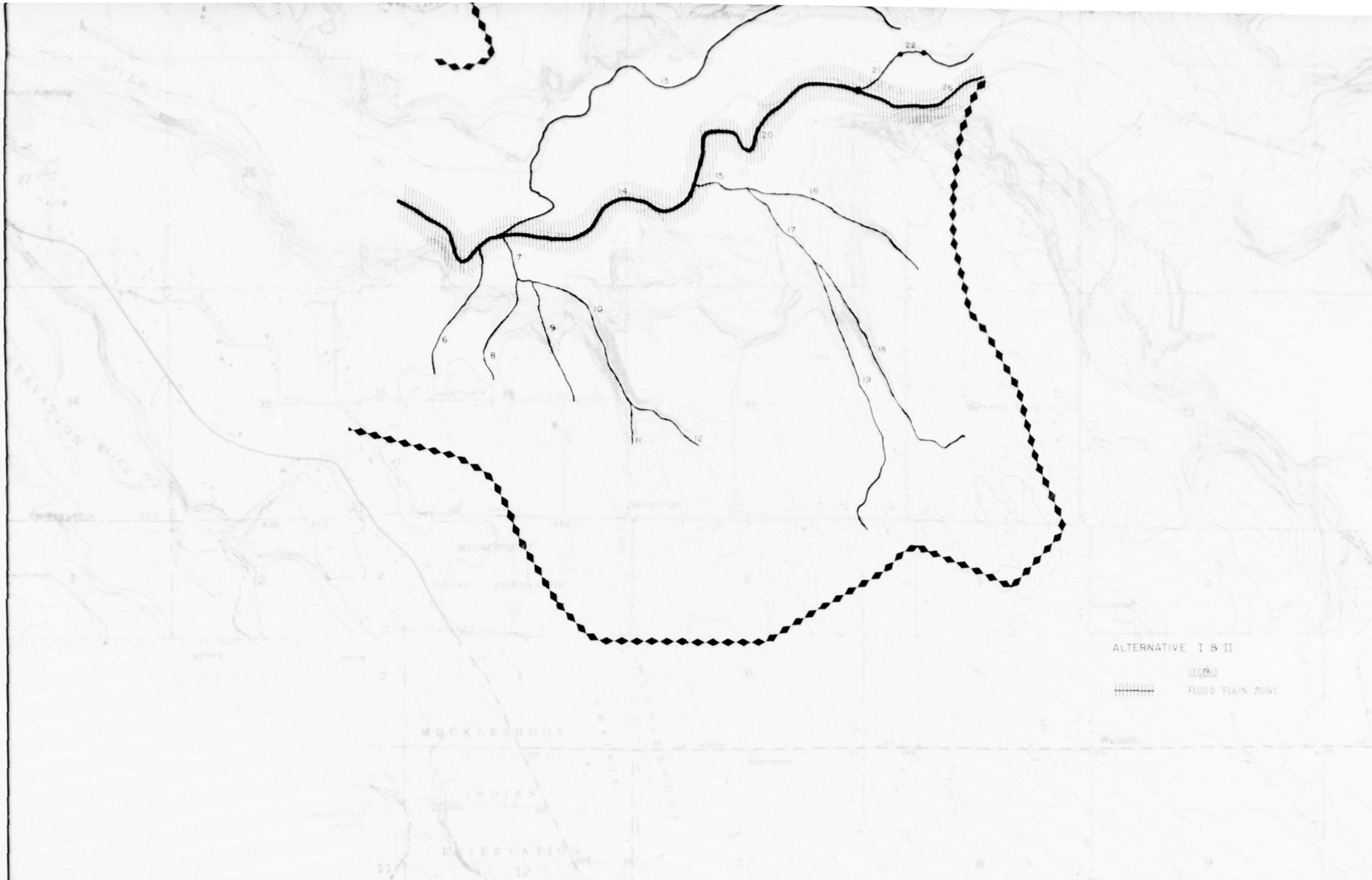

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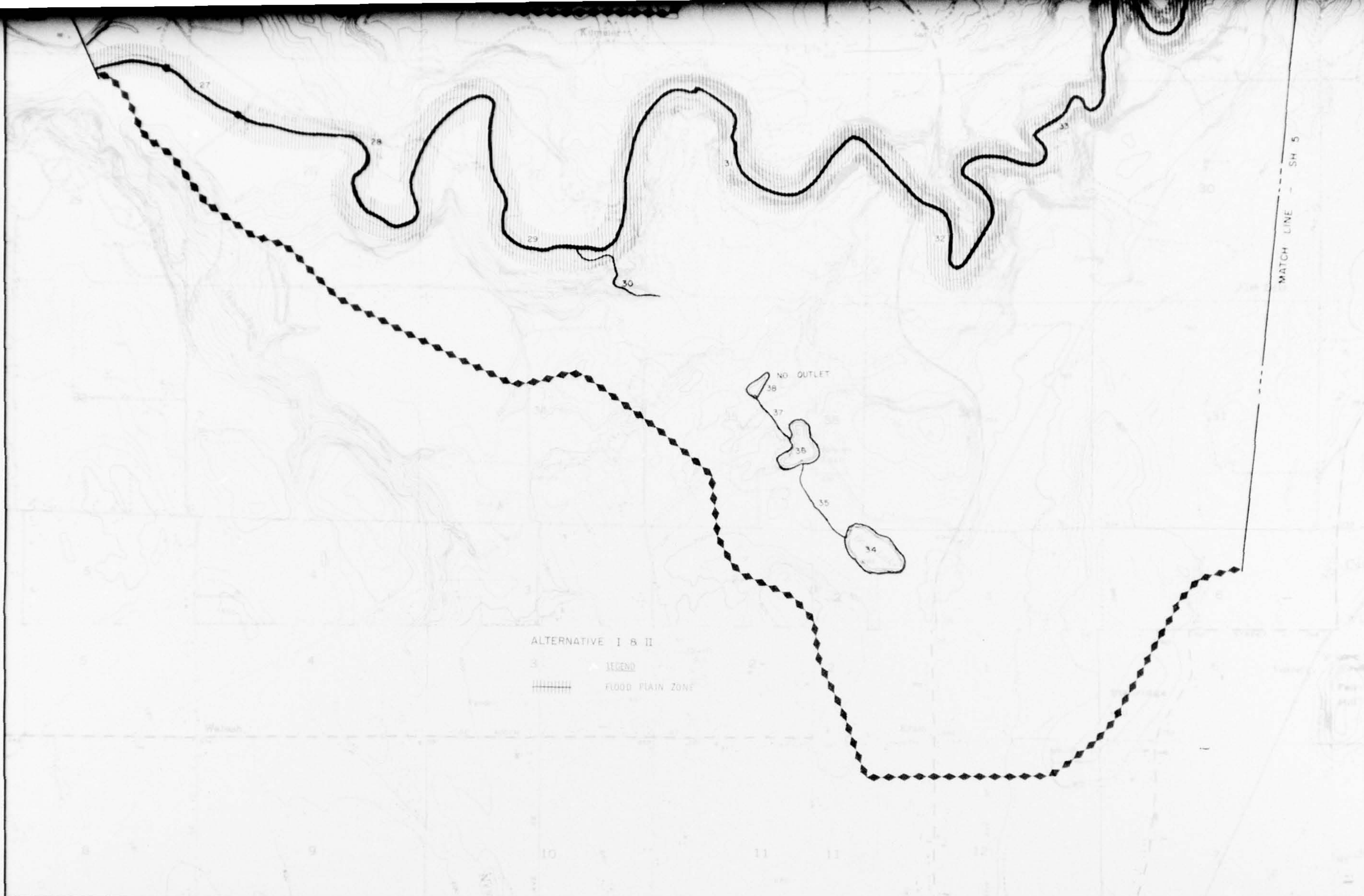

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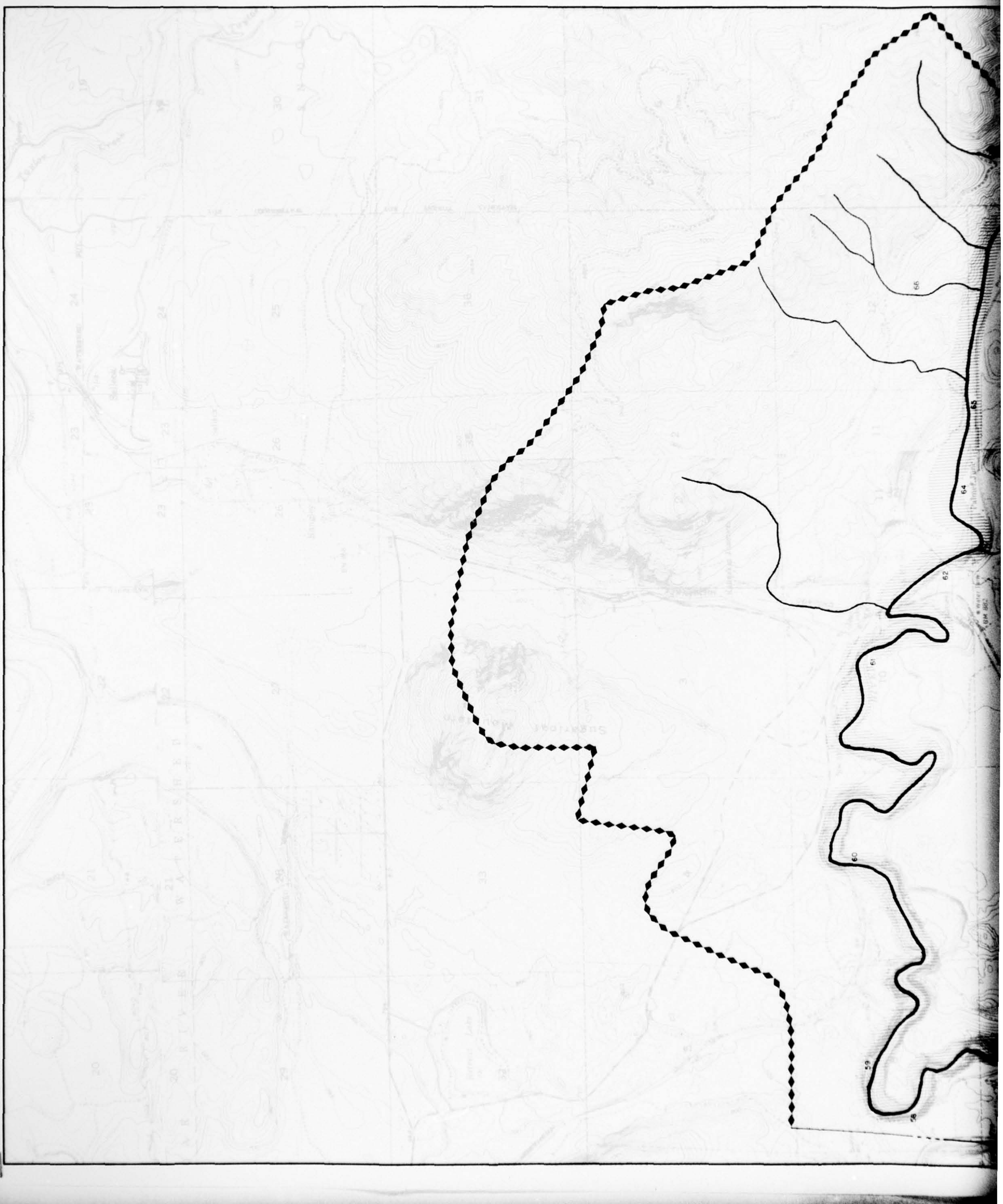

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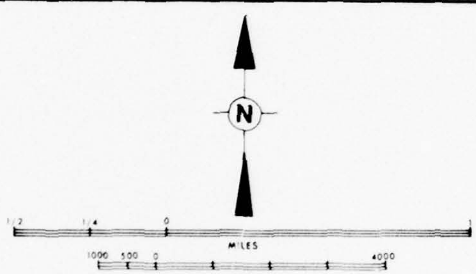

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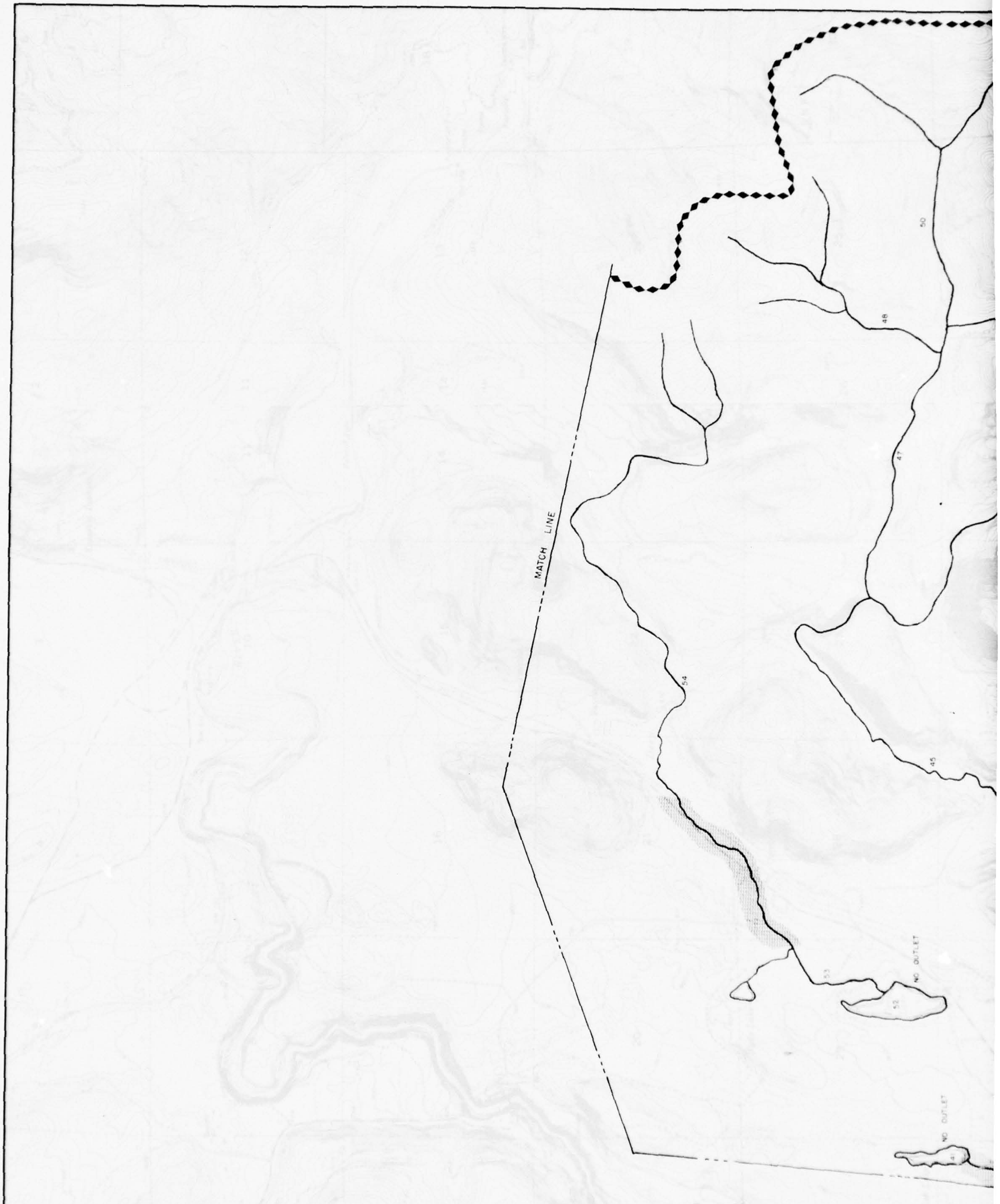

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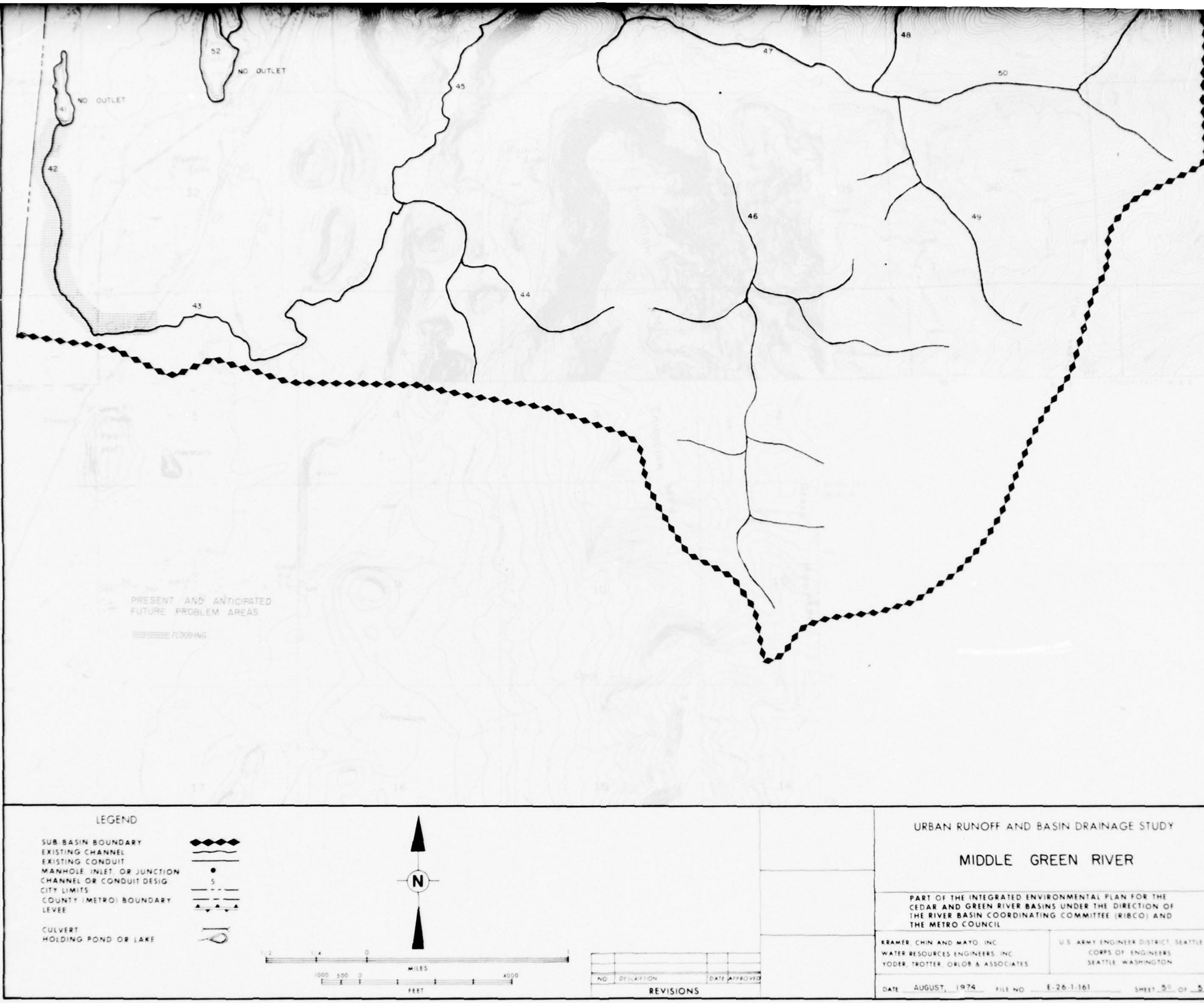

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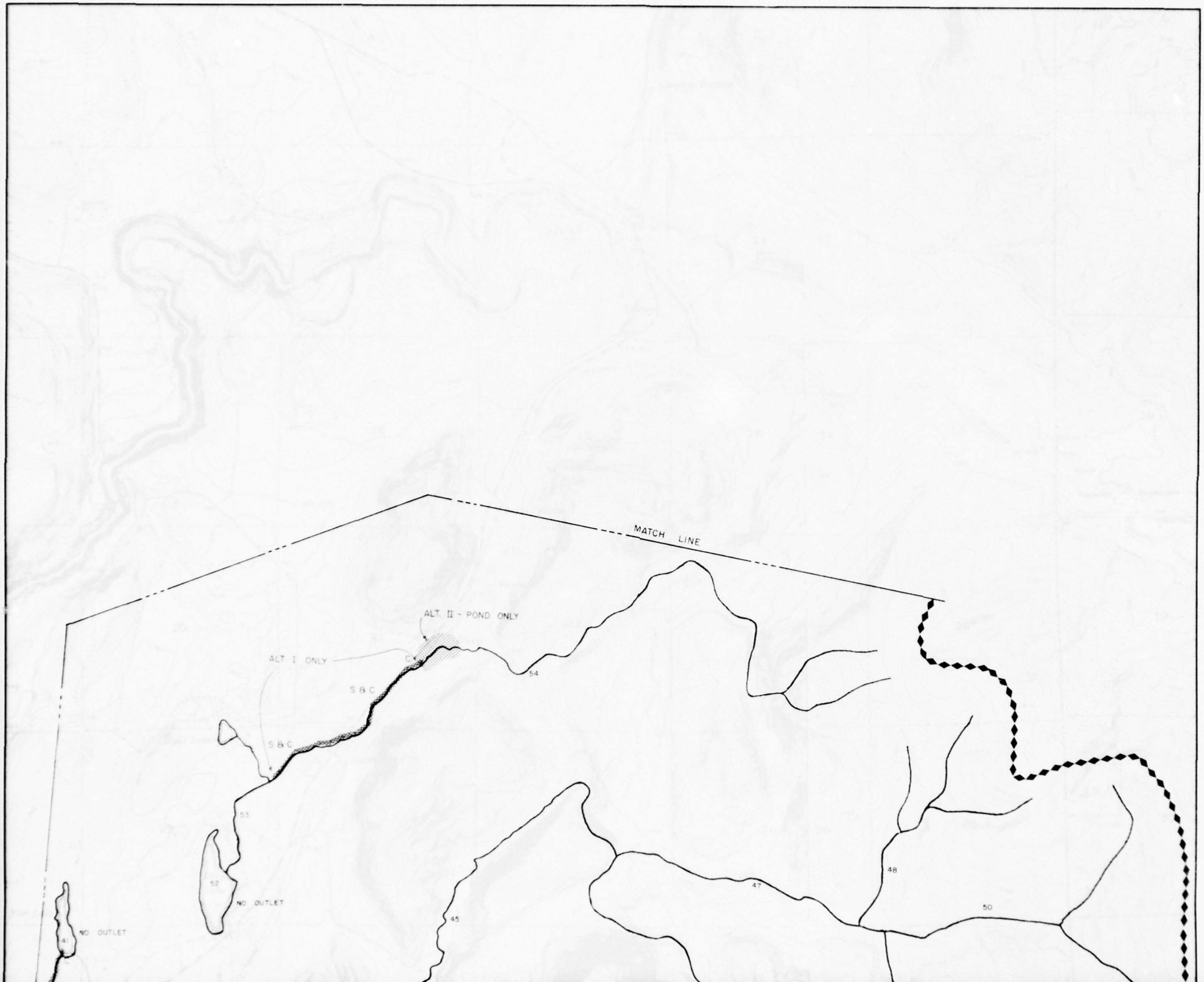
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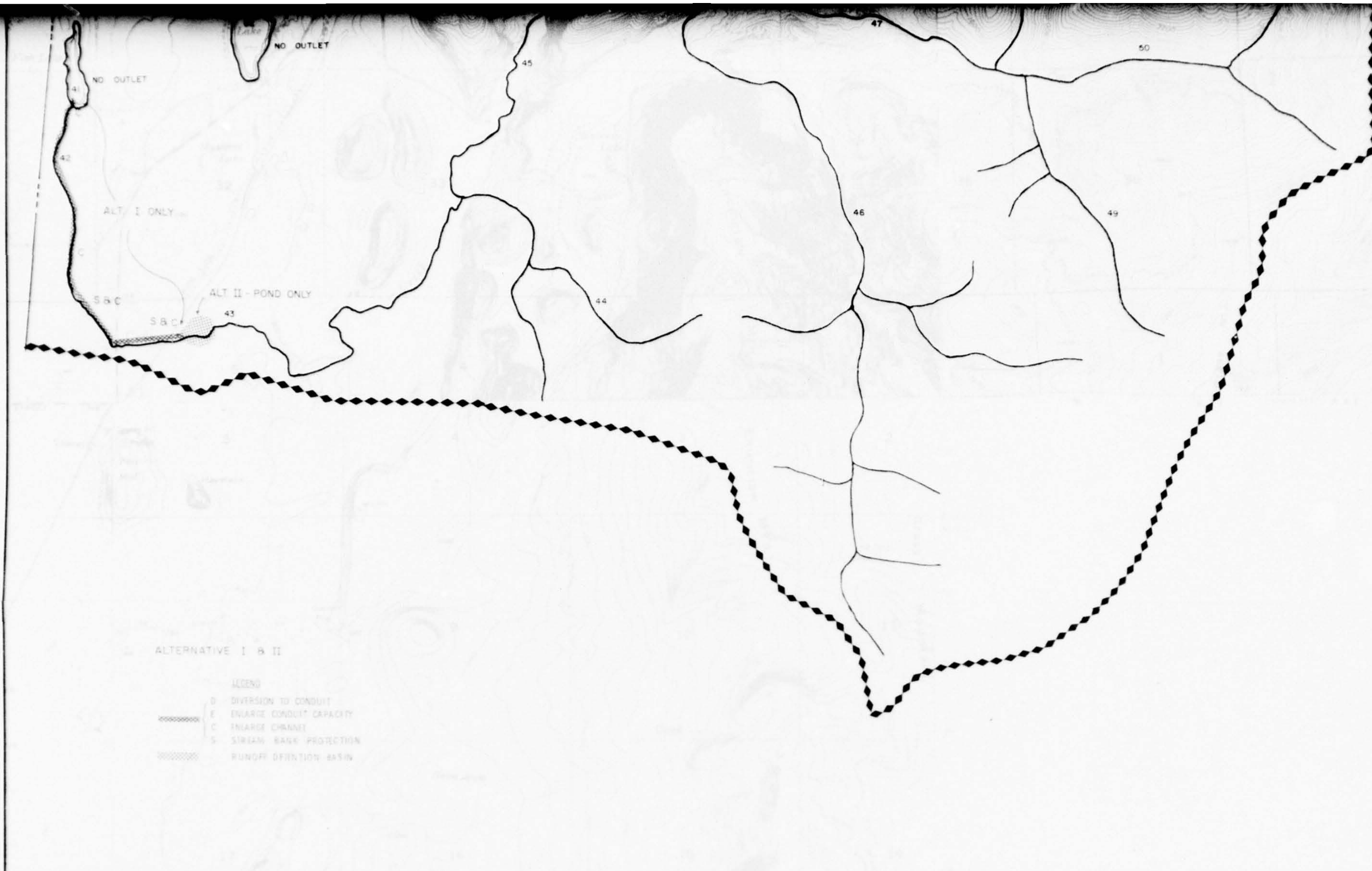

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EVALUATION MATRIX

LOWER GREEN RIVER

ALTERNATIVES	SUB TOTAL	EFFECTIVENESS: Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	SUB TOTAL	HUMAN VALUES: Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	SUB TOTAL	ENVIRONMENTAL FACTORS: High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	SUB TOTAL	IMPLEMENTATION: Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	SUB TOTAL	RESOURCE REQUIREMENTS: Energy	Materials	Land	Capital	RATING TOTAL
		CRITERIA WEIGHT 1	4	3	2	4	4	4	2		CRITERIA WEIGHT 4	2	2	1	3	3	4		CRITERIA WEIGHT 4	4	4	4	4	2	4	4	4		CRITERIA WEIGHT 4	4	2	4	4	3		CRITERIA WEIGHT 3	3	2	2	
I	-15									-3								-18										-3							-10					-49
II	-11									+1								-14										-3							-10					-37

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Lower Green River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
127	Pipe	54"	2,100'			Parallel Pipe	30"	$114,000
149	Pipe	24"	500'			Parallel Pipe	24"	$21,000
5	Pipe	30"	1,000'			Parallel Pipe	36"	$66,000
10	Pipe	24"	1,800'			Parallel Pipe	30"	$97,000
9	Pipe	48"	1,600'			Parallel Pipe	60"	$192,000
3	Pipe	48"	1,500'			Parallel Pipe	60"	$180,000
15	Pipe	42"	500'			Parallel Pipe	54"	$53,000
16	Pipe	36"	500'			Parallel Pipe	54"	$53,000
17	Pipe	30"	800'			Parallel Pipe	48"	$53,000
19	Pipe	42"	1,000'			Parallel Pipe	30"	$54,000
20	Pipe	36"	800'			Parallel Pipe	36"	$53,000
13	Pump Outlet	22 cfs		(To be re-placed)		Pump	P-17 pump station 115 cfs	$254,000
26	Pipe	5' 4.5' 5.5'	800' 540' 570'			Parallel Pipe	66"	$243,000
24	None		(parallels Pipe 23)			Diversion Pipe	72"	$375,000
170	None		(parallels Pipe 32)			Diversion Pipe	72"	$120,000
171	None					Channel	2,500 width 4' depth 2:1 side slopes 4'	$33,000
28	Channel	4'	3,400'	2:1	5'	Diversion Pipe	48" 800'	$74,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Lower Green River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
520	None					Channel	4' width 4' depth 2:1 side slopes 5,000'	$18,000
37	Channel Outlet	3'	50'	3:1	3'	Pump	P-6 pump station 80 cfs	$184,000
37	Channel	3'	300'	3:1	3'	Forebay Pond	4 AF 1 acre	$43,000
521		None				Channel	4' width 4' depth 2:1 side slopes 4,000'	$15,000
43	Channel	4'	4,000'	2:1	3'	Channel	4' width 2' depth 2:1 side slopes channel lining	$88,000
43	Channel	4'	500'	2:1	4'	Levees	12' top width 5' high 3:1 side slopes	$26,000
522	None					Pump	P-24 pump station 20 cfs	$46,000
522	None					Forebay Pond	4' width 6' depth 1,500' 1.4 AF	$35,000
523	None					Pipe	inverted siphon 3' diameter 200'	$19,000
524	None					Channel	3' width 3' depth 2:1 side slopes	$16,000
45	Channel	Open outlet to Green River				Levee	12' top width 4' high 3:1 side slopes 1,500'	$31,000
800	Channel	Open outlet to Green River				Pump	P-4 pump station 450 cfs	$945,000**
800	Channel	10'	1,000'	2:1	6'	Forebay Pond	170' width 1,000' length 23 AF	$237,000
801	Channel	10'	2,500'	2:1	4'	Channel	10' width 8' depth 2:1 side slopes	$126,000
803	None					Channel	P-12 channel 6' width 6' depth 2:1 side slopes	$109,000
802	None					Channel	P-4 system 10' width 6' depth 1,000'	$33,000
804	None					Channel	P-13 system 10' width 6' depth 3,300'	$109,000

** Represents that portion of the total pumping plant cost required to accommodate runoff from the Lower Green River Sub-basin. The other portion is included in the Mill Creek Demonstration Area costs.

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub-Basin Lower Green River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
57	Channel	4'	1,600'	3:1	3.5'	Channel	P-13 system 8' width 6' depth 2:1 side slopes	$25,000
60	Channel	4'	3,600'	3:1	4'	Channel	P-13 system 6' width 5' depth 2:1 side slopes	$13,000
64	Channel	4'	8,000'	2:1	4'	Diversion Pipe	30" 3,000'	$162,000
49	Channel	2'	2,000'	2:1	4'	Channel	4' width 3' depth 2:1 side slopes Channel lining	$58,000
53	Channel	2'	3,000'	2:1	4'	Diversion Pipe	30"	$162,000
52	Channel	2'	2,000	2:1	4'	Diversion Pipe	30"	$108,000
54	Channel	2'	4,200'	2:1	4'	Diversion Pipe	30" 4,000'	$216,000
125	Channel	4'	4,200'	2:1	4'	Channel	4' width 2' depth 3,000' Channel lining	$64,000
61	Channel	3'	3,800'	2:1	4'	Channel	3' width 2' depth 3,000' Channel lining	$53,000
840	Outlet	Open outlet to Green River				Pump	P-7 pump station 200 cfs.	$450,000**
841	Channel	8'	1,600'	2:1	6'	Forebay Pond	10 AF 2.2 Ac.	$151,000
842 843	None					Channel	8' width 6' depth 2:1 side slopes 3,000' combined length	$91,000
844	None					Channel	6' width 5' depth 2:1 side slopes 2,800'	$58,000
845 848 846 847	None					Channel	2' width 4' depth 2:1 side slopes 6,100' combined length	$67,000
89	Channel	4'	5,500'	1:1	4'	Channel	4' width 3' depth 4,500' Channel lining	$131,000
210	Channel	4'	3,000'	1:1	4'	Channel	4' width 2' depth 2,000' Channel lining	$39,000
211	Channel	4'	4,000'	1:1	4'	Diversion Pipe	24" 4,500'	$189,000

** Represents that portion of the total pumping plant cost required to accommodate runoff from the Lower Green River Sub-basin. The other portion is included in the Mill Creek Demonstration Area costs.

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Lower Green River

ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
146	Pipe	18"	2,000'			Parallel Pipe	42"	$158,000
103	Pipe	12"	1,300'			Parallel Pipe	60"	$156,000
104	Pipe	18"	1,800'			Parallel Pipe	24"	$76,000
212	Channel	6'	4,000'	1:1	4'	Diversion Pipe	36" 5,200'	$343,000
102	Pipe	18"	1,100'			Parallel Pipe	66"	$149,000
101	Pipe	18"	800'			Parallel Pipe	72"	$119,000
100	Pipe	30"	2,200'			Parallel Pipe	72"	$328,000
99	Pipe	36"	500'			Parallel Pipe	72"	$75,000
98	Pipe	36"	1,400'			Parallel Pipe	72"	$209,000
97	Pipe	42"	900'			Parallel Pipe	72"	$134,000
95	Pipe	42"	4,500'			Parallel Pipe	72"	$671,000
147	Pipe	15"	1,500'			Parallel Pipe	24"	$63,000
111	Pipe	12"	2,500'			Parallel Pipe	24"	$105,000
110	Pipe	18"	3,800'			Parallel Pipe	54"	$403,000
109	Pipe	18"	1,600'			Parallel Pipe	60"	$192,000
108	Pipe	30"	2,000'			Parallel Pipe	60"	$240,000
107	Pipe	30"	1,200'			Parallel Pipe	66"	$162,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Lower Green River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
106	Pipe	30"	300'			Parallel Pipe	66"	$41,000
118	Pipe	30"	1,500'			Parallel Pipe	66"	$203,000
120	Pipe	12"	2,300'			Parallel Pipe	48"	$214,000
119	Pipe	12"	1,300'			Parallel Pipe	48"	$121,000
117	Pipe	36"	1,200'			Parallel Pipe	72"	$179,000
116	Pipe	60"	1,900'			Parallel Pipe	66"	$257,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $10,750,000

Round To: $10,800,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Lower Green River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
5	Pipe	30"	1,000'			Parallel Pipe	36"	$66,000
149	Pipe	24"	500'			Parallel Pipe	24"	$21,000
3	Pipe	48"	1,500'			Parallel Pipe	60"	$180,000
10	Pipe	24"	1,800'			Parallel Pipe	30"	$97,000
9	Pipe	48"	1,600'			Parallel Pipe	60"	$192,000
15	Pipe	42"	500'			Parallel Pipe	54"	$53,000
16	Pipe	36"	500'			Parallel Pipe	54"	$53,000
17	Pipe	30"	800'			Parallel Pipe	48"	$74,000
19	Pipe	42"	1,000'			Parallel Pipe	30"	$54,000
20	Pipe	36"	800'			Parallel Pipe	36"	$53,000
13	Pump Outlet	22 cfs	(To be replaced)			Pump	P-17 pump station 75 cfs	$165,000
26	Pipe	5' 4.5' 5.5'	800' 540' 740'			Parallel Pipe	36"	$119,000
24		None	(parallels Pipe 23)			Diversion Pipe	60"	$300,000
170	None		(parallels Pipe 32)			Diversion Pipe	60"	$96,000
171	None					Channel	2' width 4' depth 2:1 side slopes 2,500'	$28,000
28	Channel	4'	3,400'	2:1	5'	High Press. Pipe	42" 800'	$63,000
37	Channel Outlet	3'	50'	3:1	3'	Pump	P-6 pump station 80 cfs	$184,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Lower Green River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
37	Channel	3'	300'	3:1	3'	Forebay Pond	4 AF 1 acre	$43,000
520	None					Channel	4' width 4' depth 2:1 side slopes 5,000'	$18,000
521	None					Channel	4' width 4' depth 2:1 side slopes 4,000'	$15,000
43	Hillside Stream	4'	4,000'	2:1	3'	Channel	4' width 2' depth 2:1 side slopes Channel lining	$88,000
43	Valley Stream	4'	500'	2:1	4'	Levees	12' top width 5' high 3:1 side slopes	$26,000
522	None					Pump	P-24 pump station 20 cfs	$46,000
522	None					Forebay Canal	4' width 6' depth 1,500' 1.4 AF	$35,000
523	None					Pipe siphon	Inverted siphon 36" diameter 200'	$19,000
524	None					Channel	3' width 3' depth 2:1 side slopes	$16,000
45	Channel	4'	1,500'	2:1	3'	Levee	12' top width 5' high 3:1 side slopes 1,500'	$31,000
800	Channel	Open outlet to Green River				Pump	P-4 pump station 325 cfs	$683,000
800	Channel	10'	1,000'	2:1	6'	Forebay Pond	35' width 10' depth 10 AF	$129,000
801	Channel	10'	2,500'	2:1	4'	Channel	10' width 6' depth 2:1 side slopes	$83,000
803	None					Channel	4' width 5' depth 2:1 side slopes 4,000'	$73,000
802	None					Channel	10' width 6' depth 2:1 side slopes 1,000'	$33,000
804	None					Channel	8' width 6' depth 2:1 side slopes 3,300'	$100,000
57	Channel	4'	1,600'	3:1	3.5'	Channel	8' width 6' depth 2:1 side slopes	$19,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II   Sub Basin Lower Green River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
64	Channel	4'	8,000'	2:1	4'	Diversion Pipe	24" 3,000'	$96,000
51	Lake	500'	2,000'	3:1	5'	Outlet	24" 100'	$8,000
53	Channel	2'	3,000'	2:1	4'	Diversion Pipe	30" 3,000'	$162,000
52	Channel	2'	2,000'	2:1	4'	Diversion Pipe	30" 2,000'	$108,000
54	Channel	2'	4,200'	2:1	4'	Diversion Pipe	24" 4,000'	$168,000
125	Channel	4'	4,200'	2:1	4'	Channel	4' width 2' depth 3,000' Channel lining	$64,000
62	Pond	300'	800'	10:1	5'	Pond	11.5 AF 5 Ac.	$38,000
840	Outlet	8'	100'	2:1	6'	Pump	P-7 pump station 120 cfs	$270,000
841	Channel	8'	1,600'	2:1	6'	Forebay Pond	8 AF 2 Ac.	$121,000
842 843	None					Channel	6' width 6' depth 2:1 side slopes 3,000'	$82,000
844	None					Channel	4' width 4' depth 2:1 side slopes 2,800'	$37,000
845 846 847 848	None					Channel	2' width 3' depth 2:1 side slopes 6,100'	$43,000
89	Channel	4'	5,500'	1:1	4'	Channel	3' width 2' depth 4,500' length Channel lining	$88,000
210	Channel	4'	3,000'	1:1	4'	Channel	4' width 2' depth 2,000' length Channel lining	$39,000
211	Channel	4'	4,000'	1:1	4'	Diversion Pipe	24" 4,500'	$189,000
212	Channel	6'	4,000'	1:1	4'	Diversion Pipe	30" 5,200'	$281,000
146	Pipe	18"	2,000'			Parallel Pipe	42"	$158,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Lower Green River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
103	Pipe	12"	1,300'			Parallel Pipe	60"	$156,000
104	Pipe	18"	1,800'			Parallel Pipe	24"	$76,000
102	Pipe	18"	1,100'			Parallel Pipe	66"	$148,000
101	Pipe	18"	800'			Parallel Pipe	66"	$108,000
100	Pipe	30"	2,200'			Parallel Pipe	72"	$328,000
99	Pipe	36"	500'			Parallel Pipe	72"	$75,000
98	Pipe	36"	1,400'			Parallel Pipe	72"	$209,000
97	Pipe	42"	900'			Parallel Pipe	72"	$134,000
95	Pipe	42"	4,500'			Parallel Pipe	72"	$671,000
147	Pipe	15"	1,500'			Parallel Pipe	24"	$63,000
111	Pipe	12"	2,500'			Parallel Pipe	24"	$105,000
110	Pipe	18"	3,800'			Parallel Pipe	54"	$403,000
109	Pipe	18"	1,600'			Parallel Pipe	60"	$192,000
108	Pipe	30"	2,000'			Parallel Pipe	60"	$240,000
107	Pipe	30"	1,200'			Parallel Pipe	66"	$162,000
106	Pipe	30"	300'			Parallel Pipe	66'	$41,000
118	Pipe	30"	1,500'			Parallel Pipe	66"	$203,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

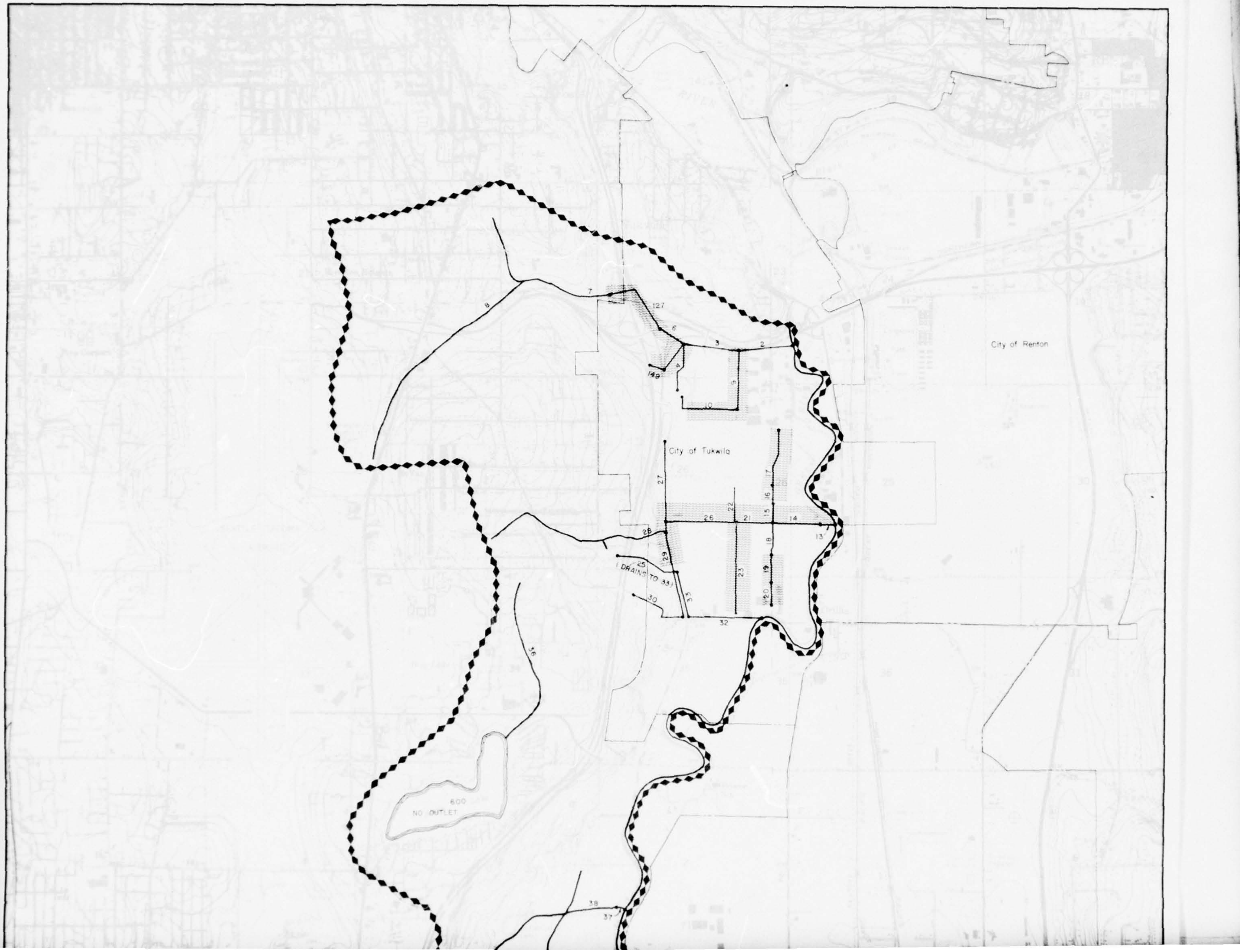
Alternative II Sub Basin Lower Green River

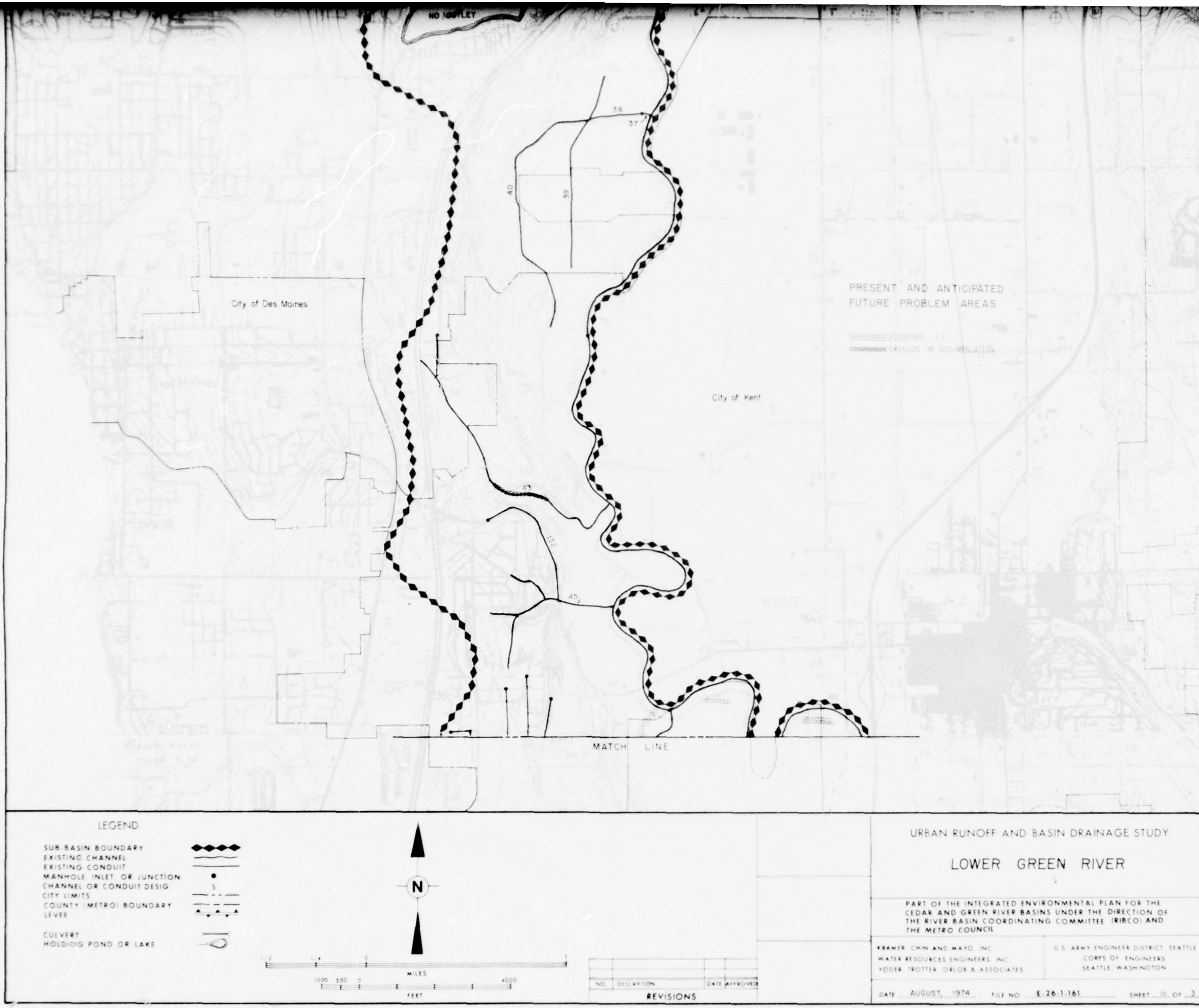
ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
120	Pipe	12"	2,300'			Parallel Pipe	48"	$214,000
119	Pipe	12"	1,300'			Parallel Pipe	48"	$121,000
117	Pipe	36"	1,200'			Parallel Pipe	72"	$179,000
116	Pipe	60"	1,900'			Parallel Pipe	66"	$257,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $9,292,000

Round To: $9,300,000


City of Renton
City of Tukwila
(DRAINS TO 33)
600
NO OUTLET



NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER GREEN RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 10 OF 3

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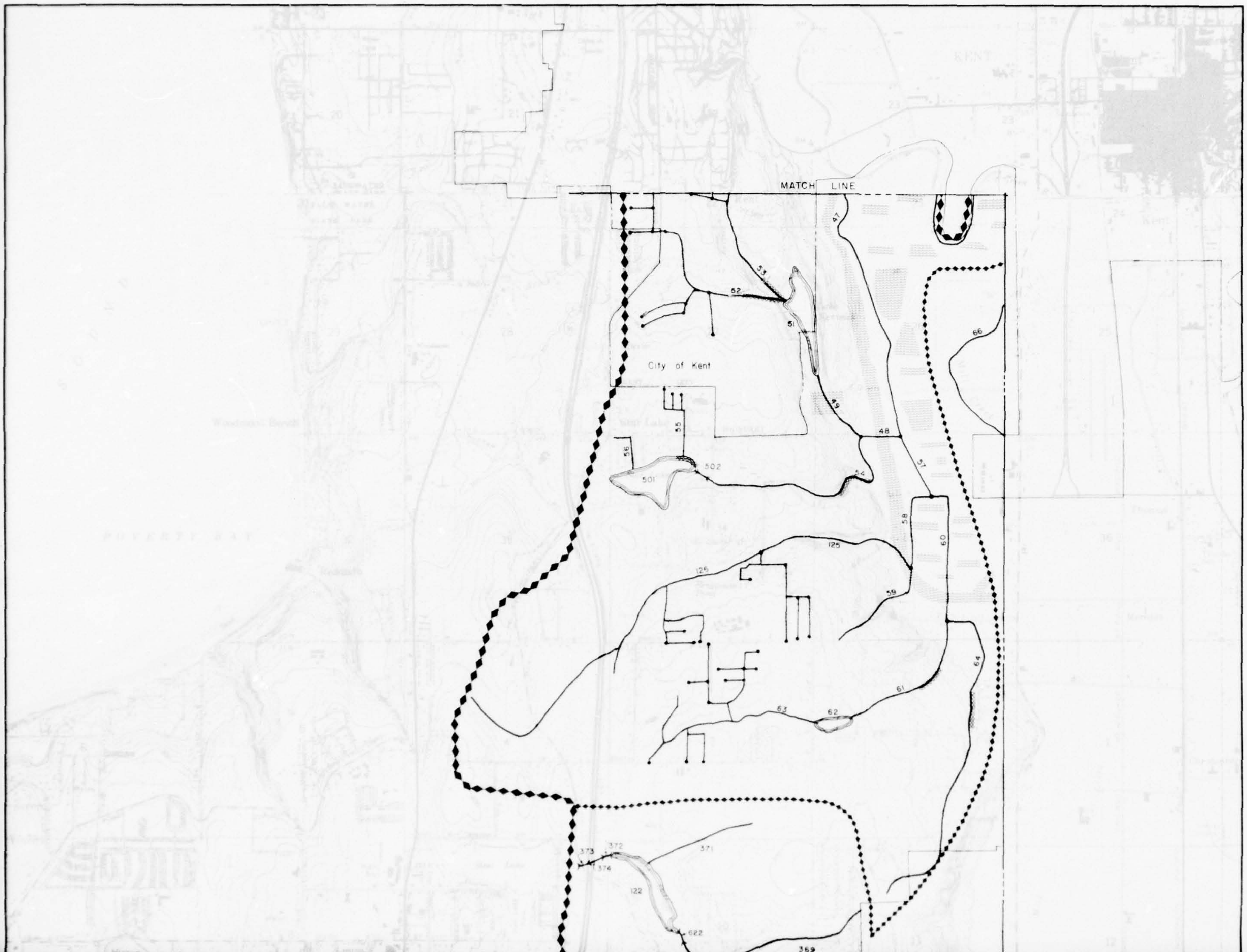
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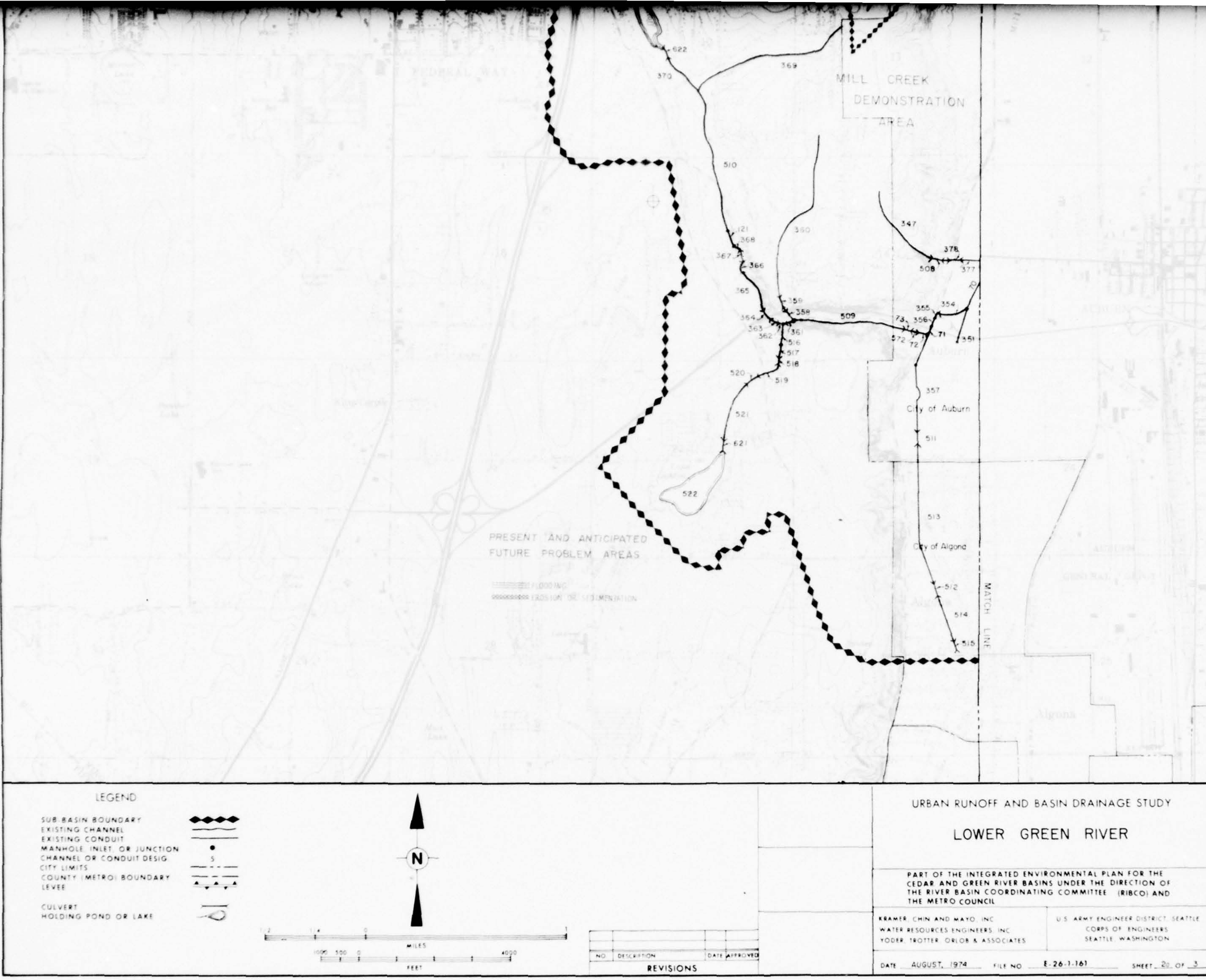
City of Kent



NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER GREEN RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2a OF 3

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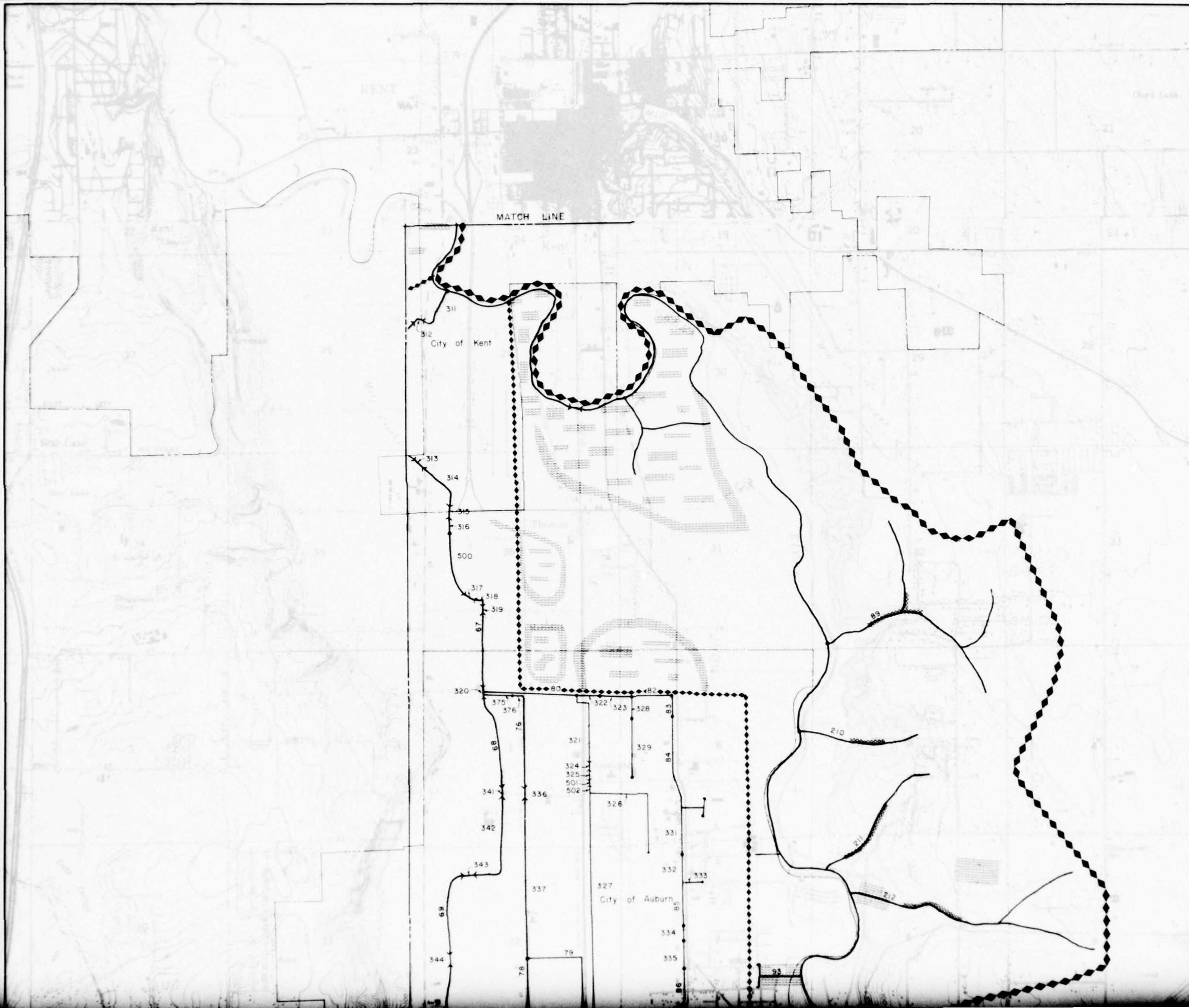
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City of Kent
City of Auburn
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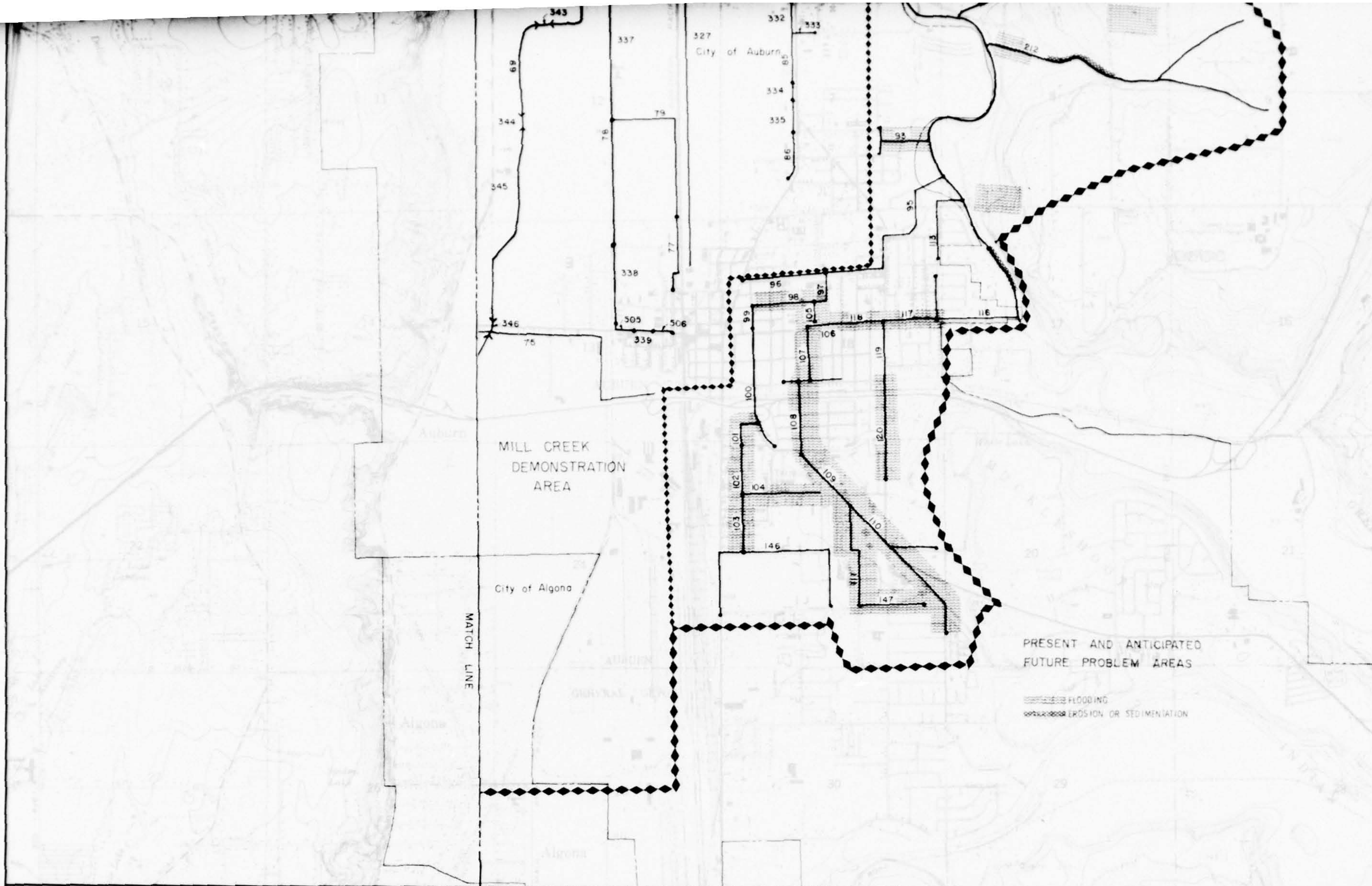

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER GREEN RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 3 OF 3

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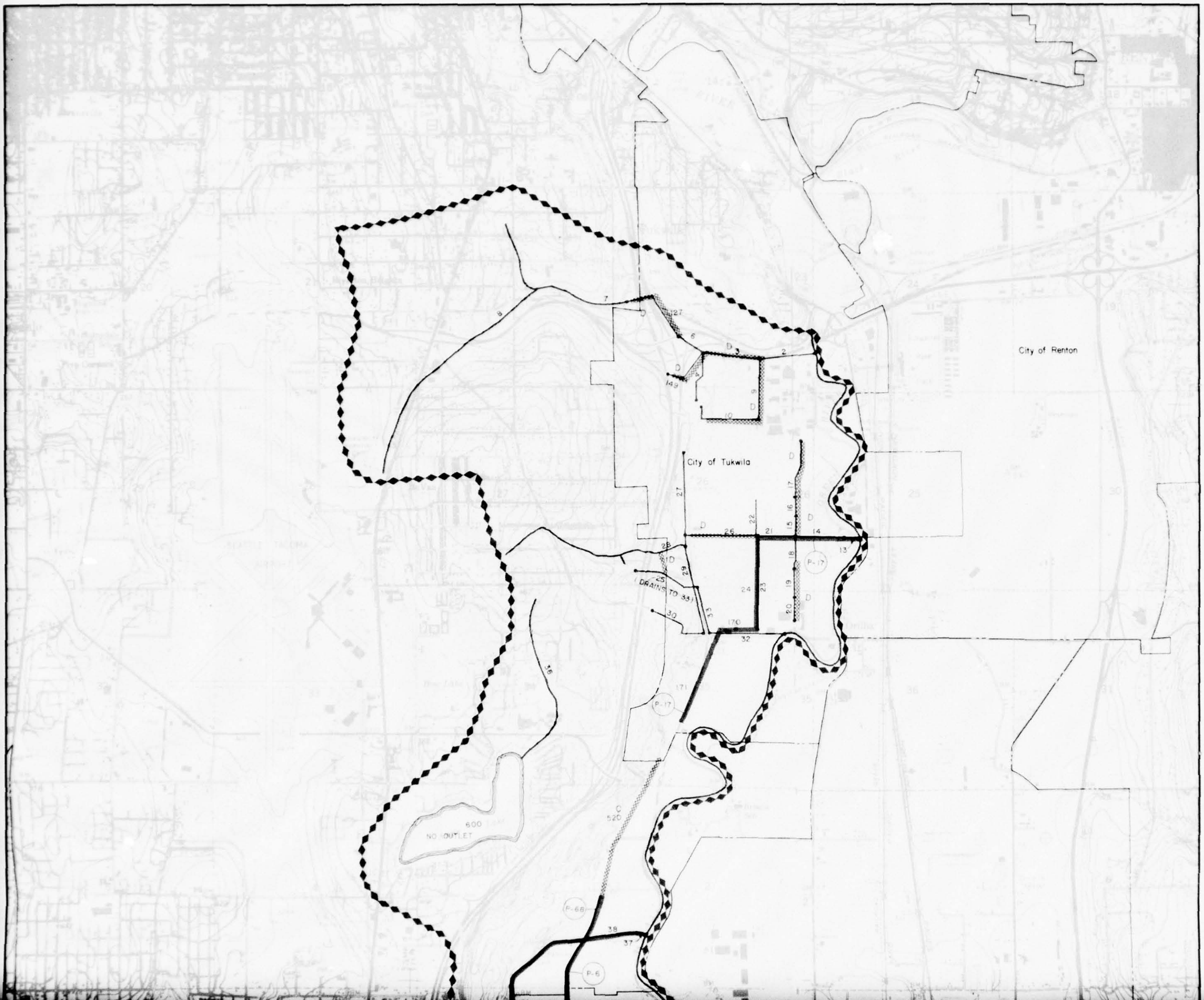
City of Renton
City of Tukwila
(DRAINS TO 33)
NO OUTLET
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P-17
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P-6B

LEGEND

SUB-BASIN BOUNDARY	
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FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER GREEN RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1b OF 3

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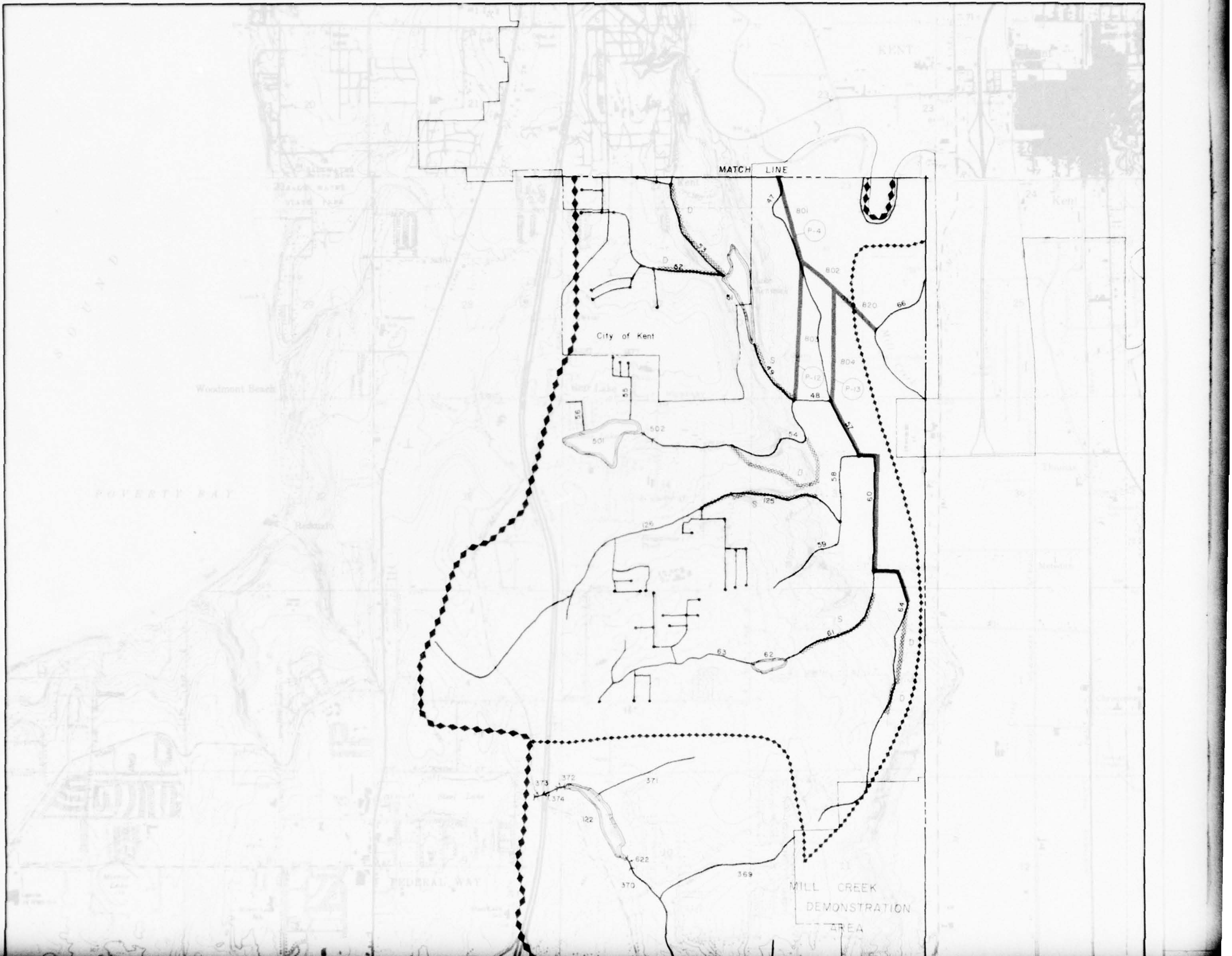
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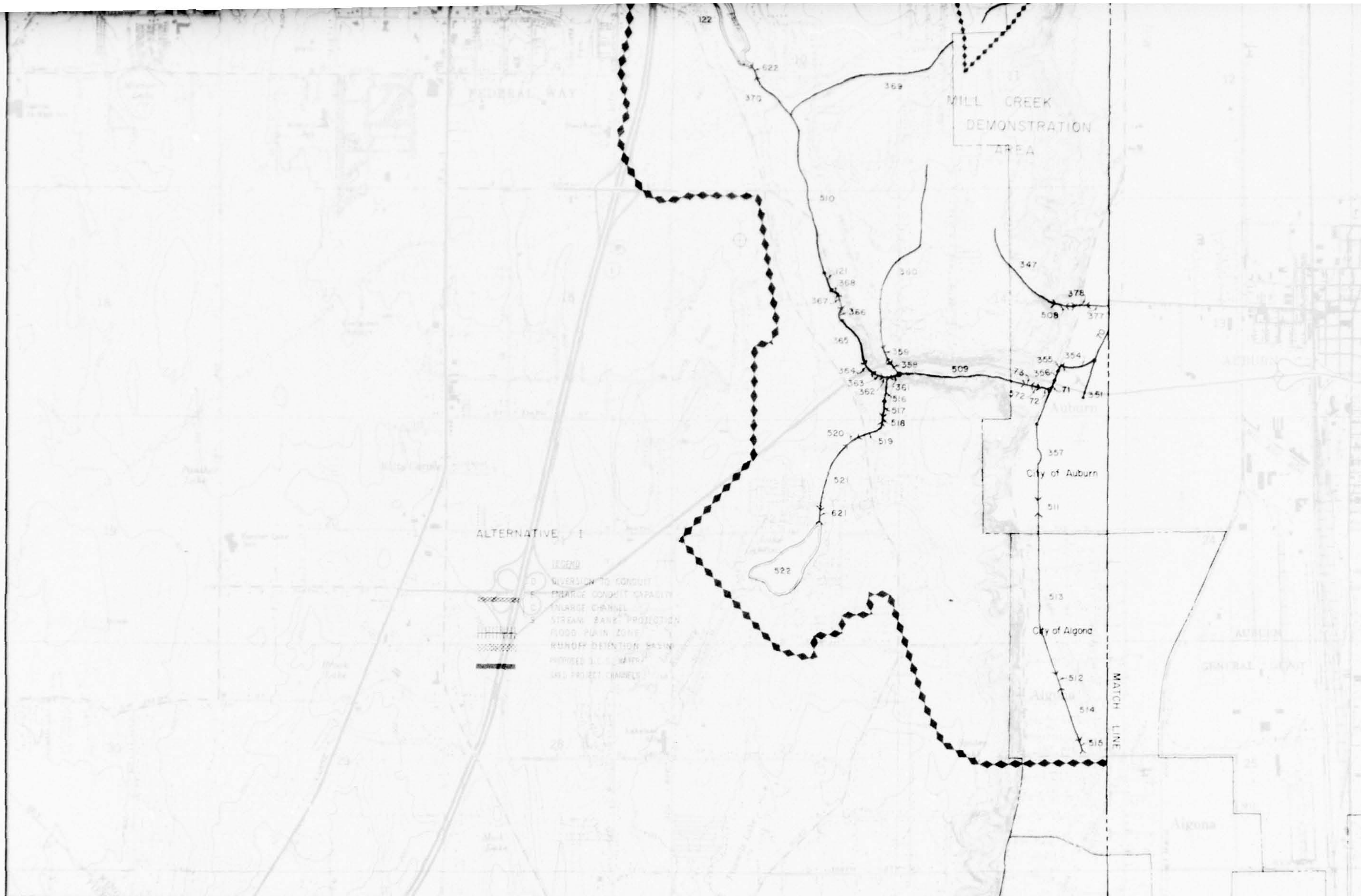
City of Kent
MILL CREEK DEMONSTRATION AREA
KENT
Woodmont Beach
POVERTY BAY
FEDERAL WAY



LEGEND

SUB BASIN BOUNDARY
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EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

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HOLDING POND OR LAKE

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NO.	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER GREEN RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

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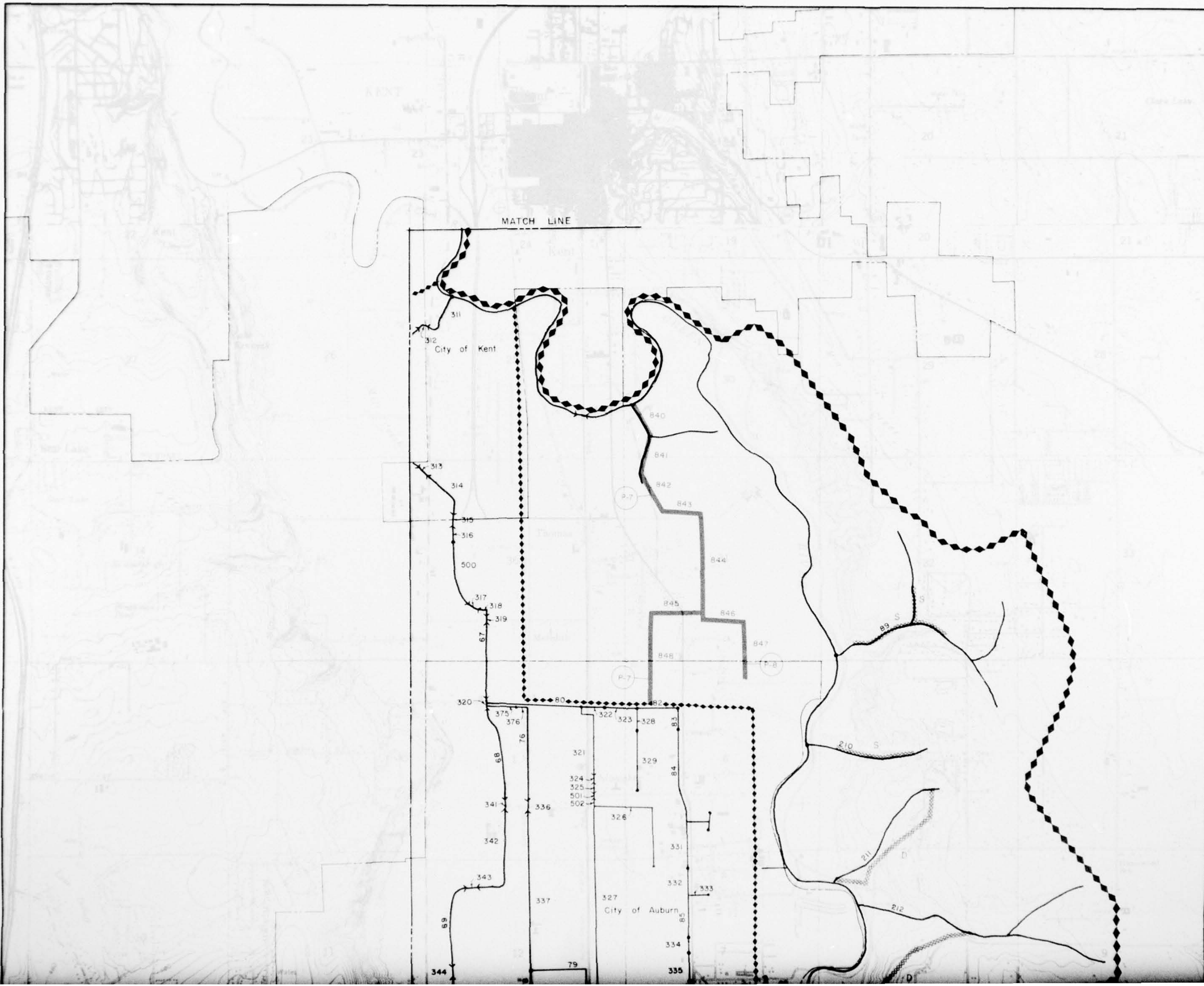
MATCH LINE
City of Kent
City of Auburn
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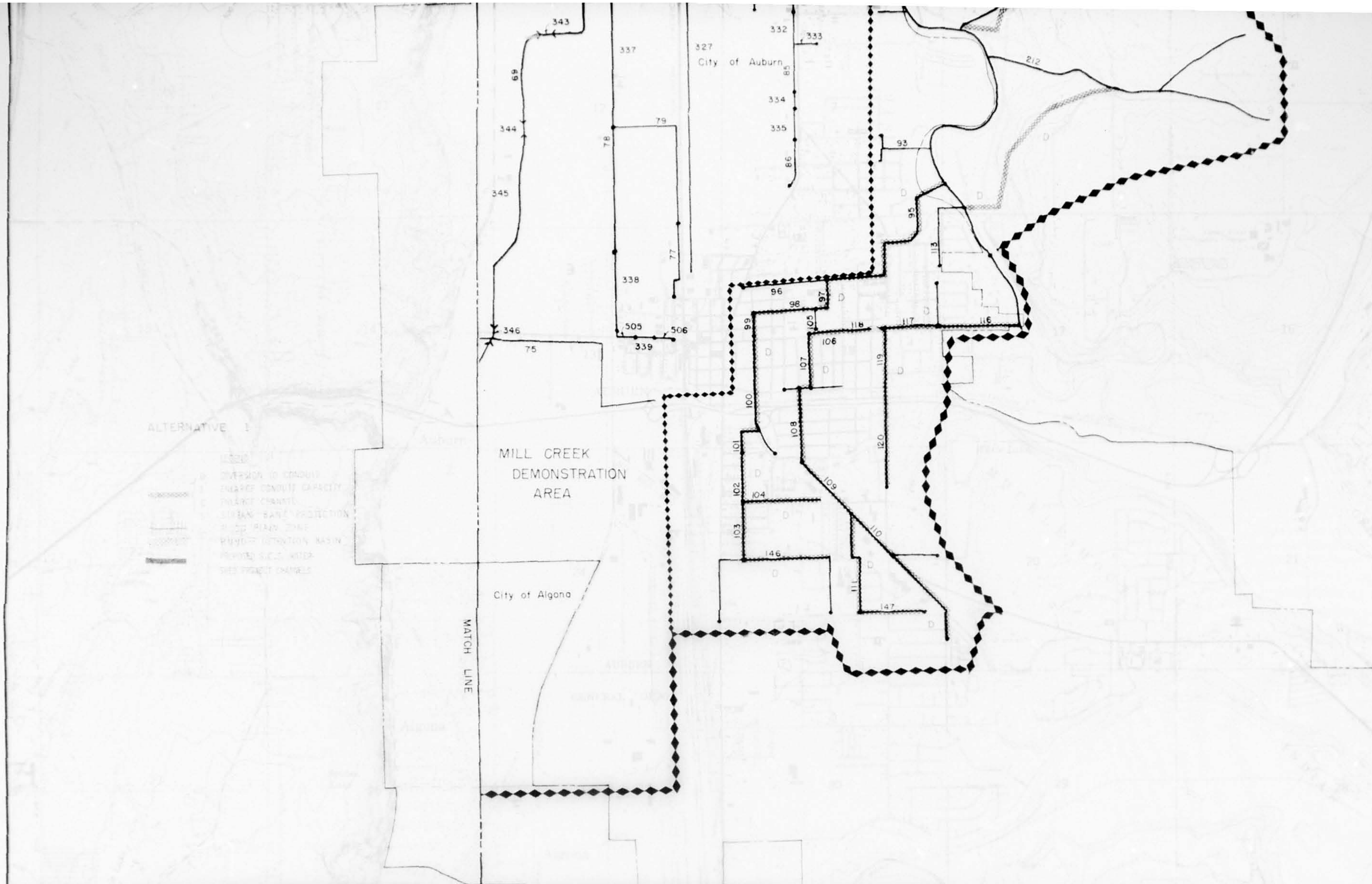


LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

MILES

FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

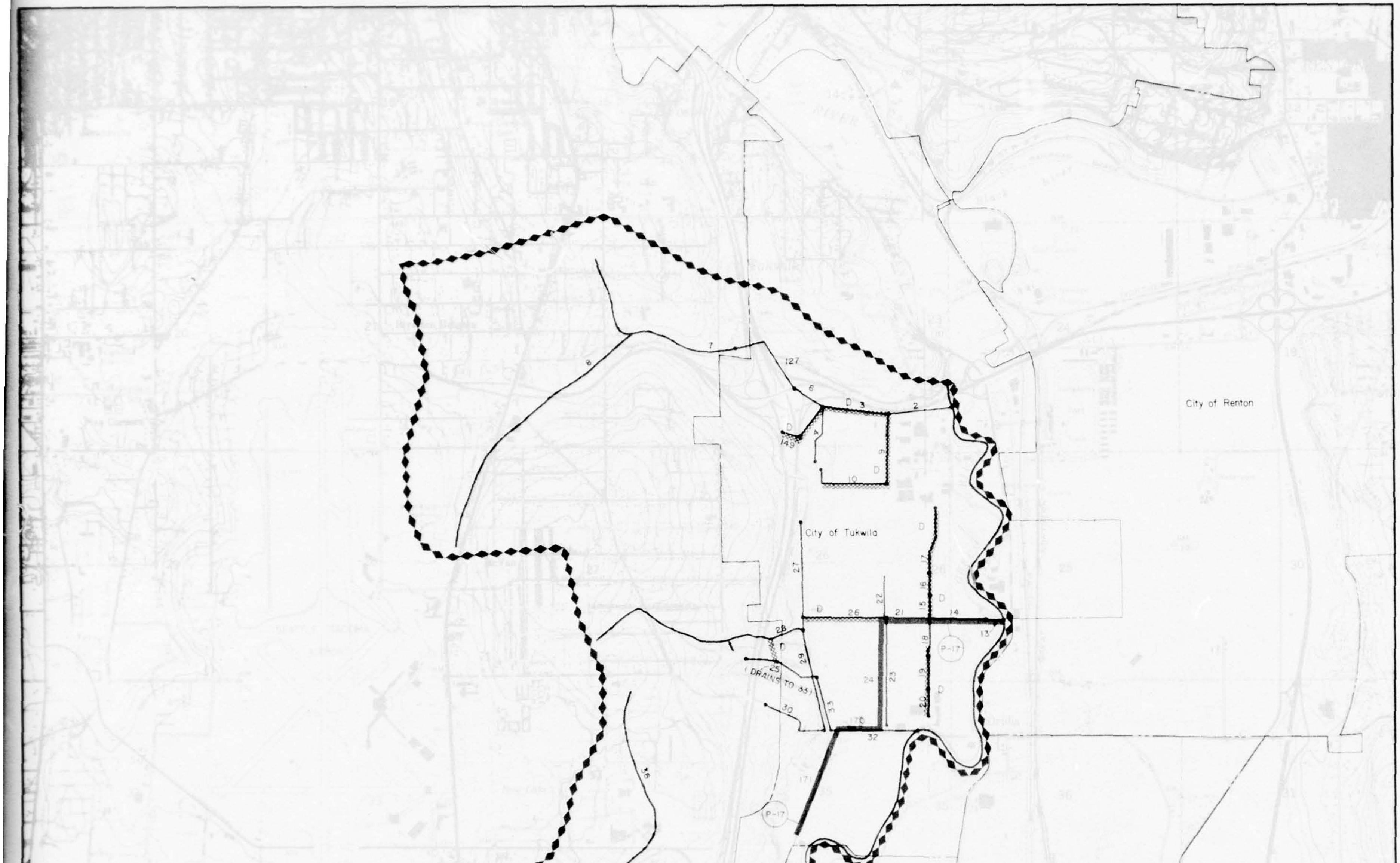
LOWER GREEN RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

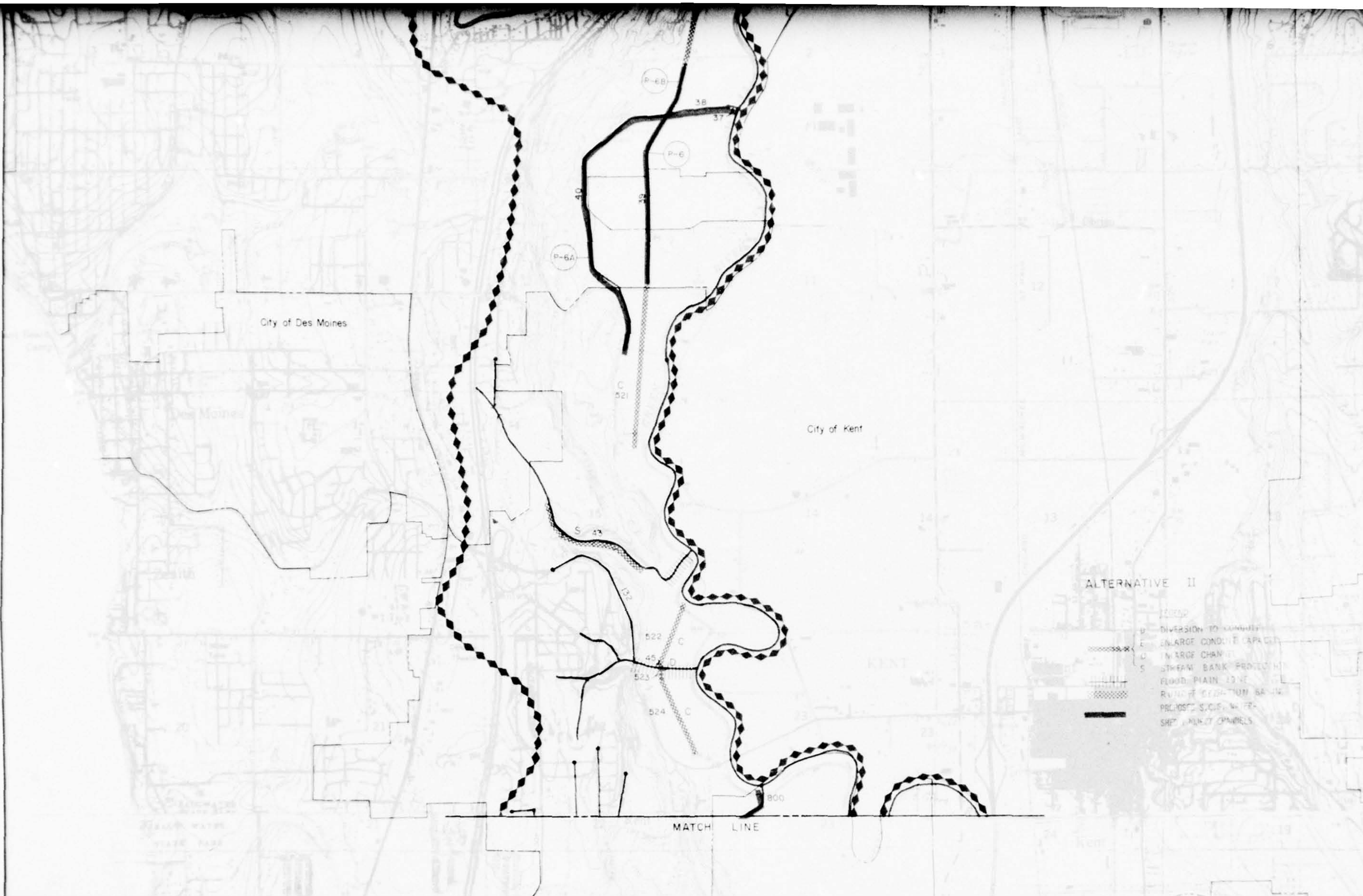
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 3 OF 3



City of Renton
City of Tukwila
P-17
P-17
P-6
P-6B
DRAINS TO 33
600
NO OUTLET
520



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER GREEN RIVER

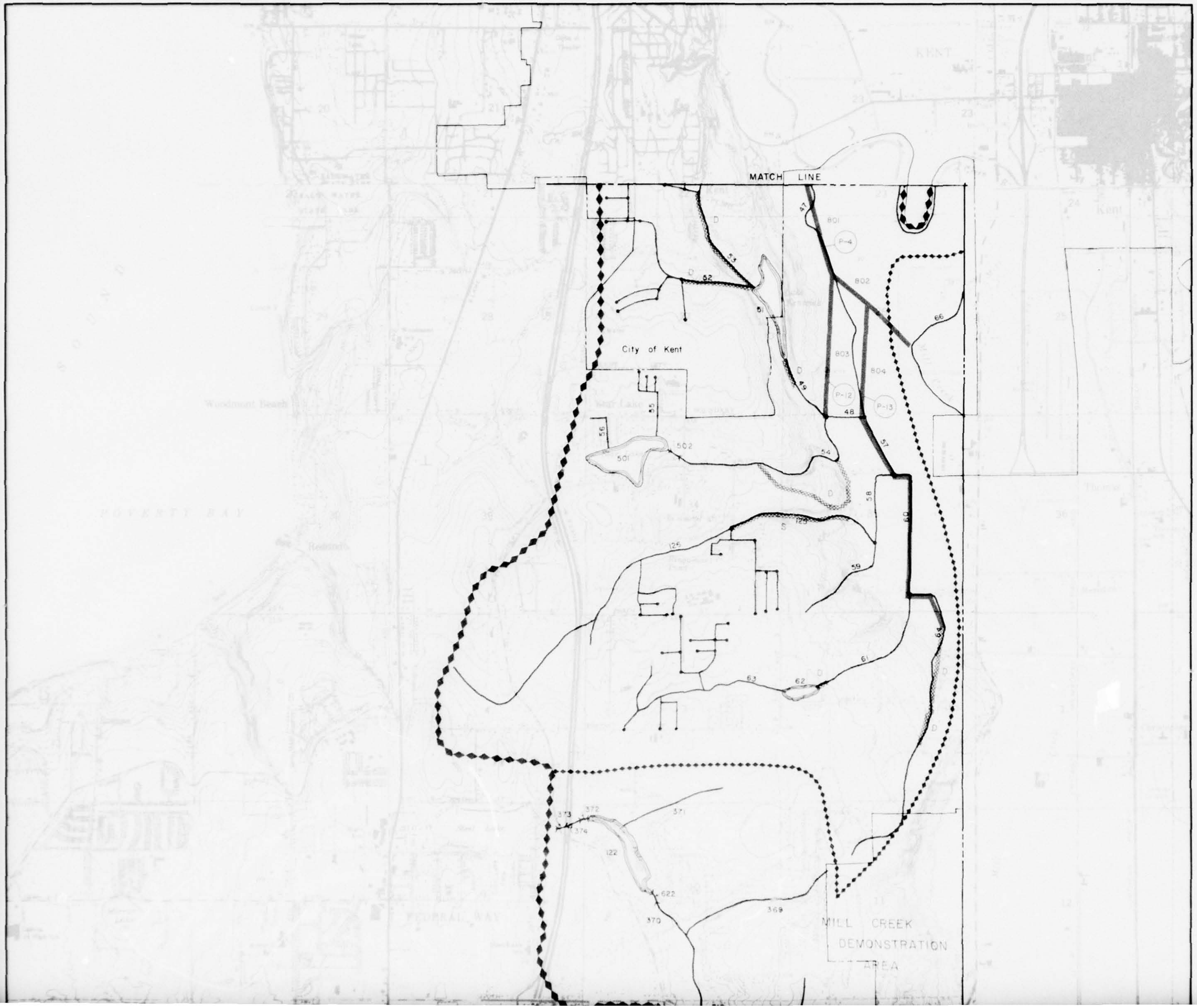
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF *THE RIVER BASIN COORDINATING COMMITTEE* (RIBCO) AND THE METRO COUNCIL

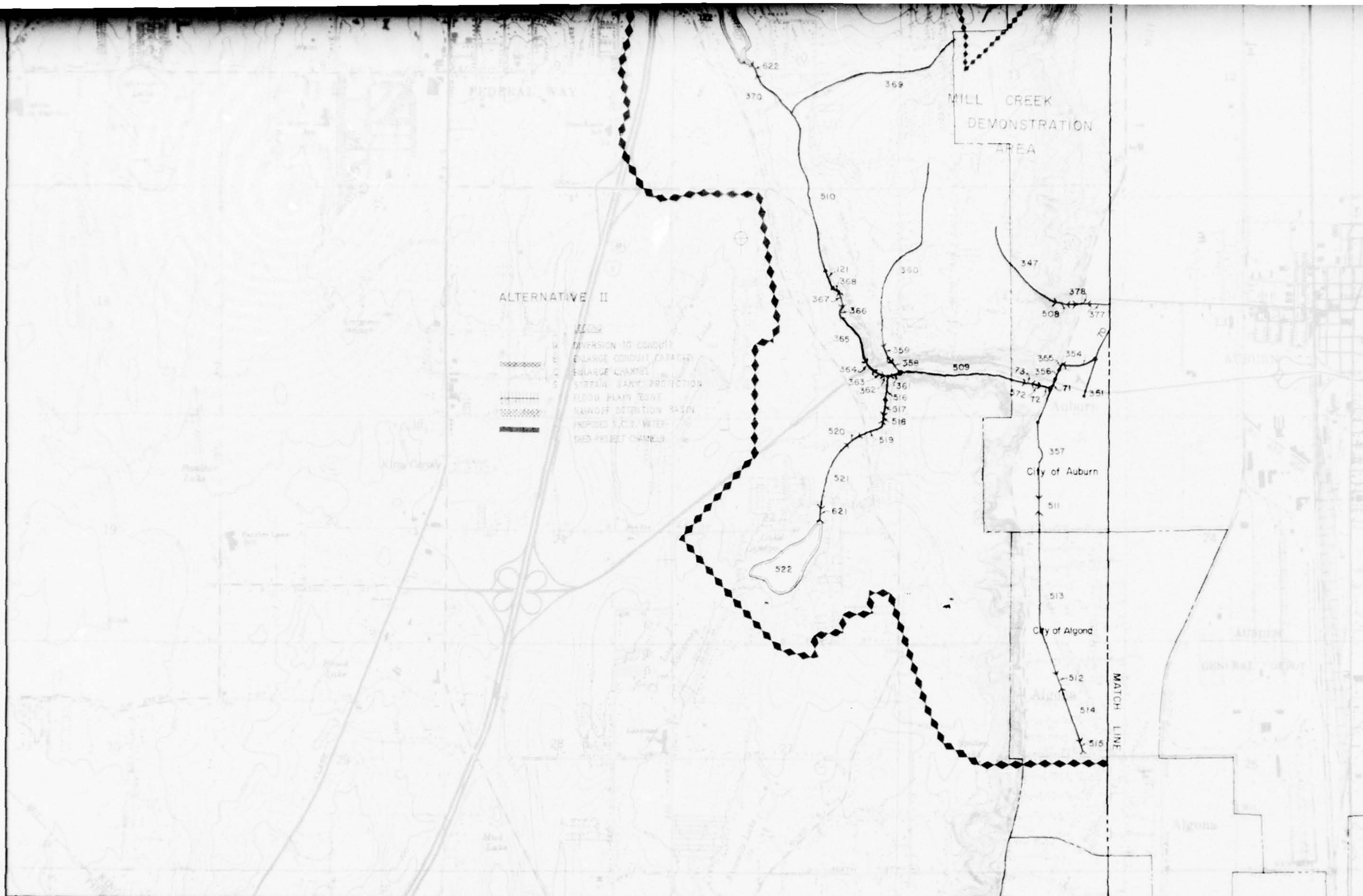
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1 OF 3

2


MATCH LINE
City of Kent
MILL CREEK
DEMONSTRATION
AREA



LEGEND

- SUB BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG.
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

MILES 1/2 1/4 0 1

FEET 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER GREEN RIVER

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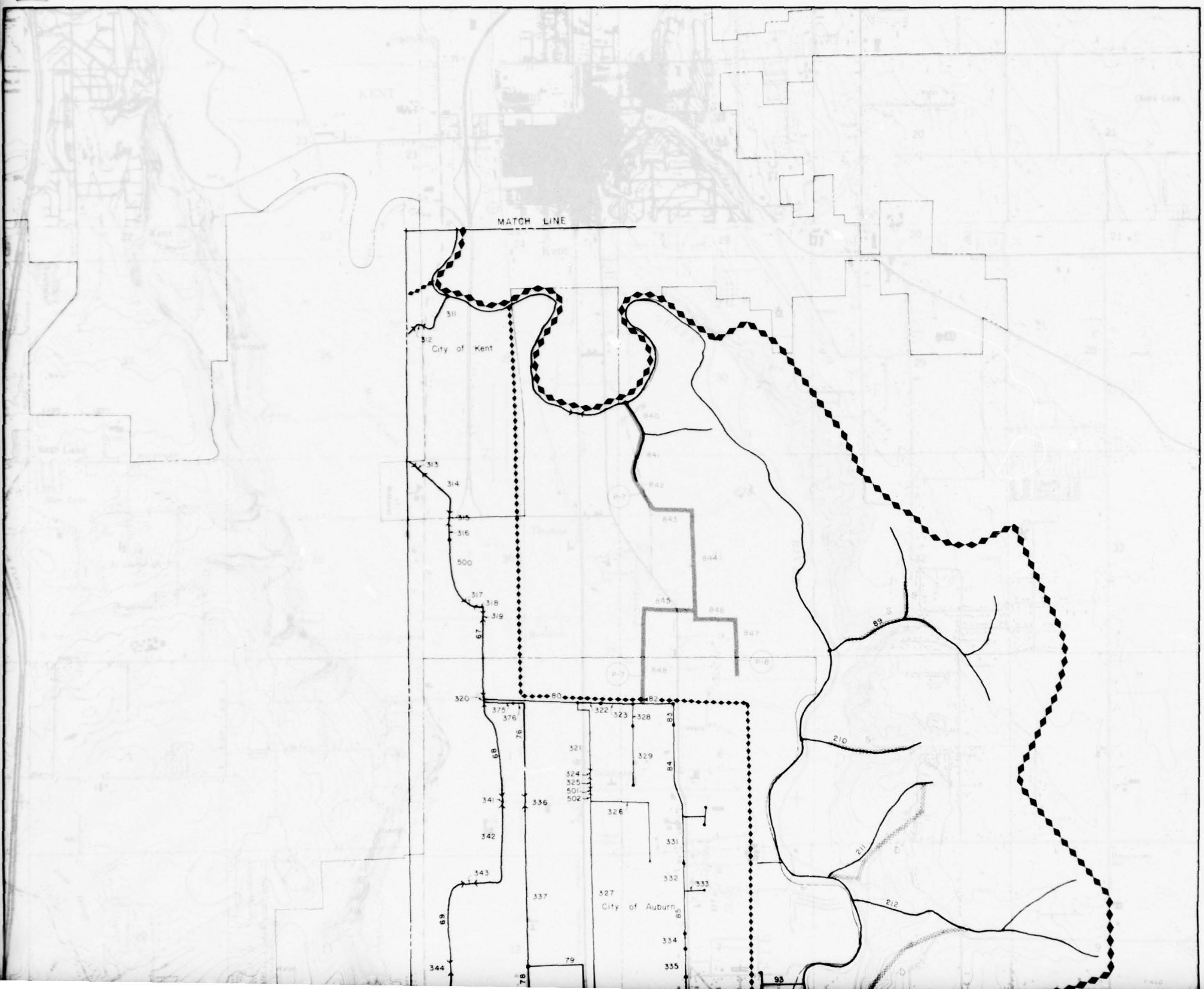
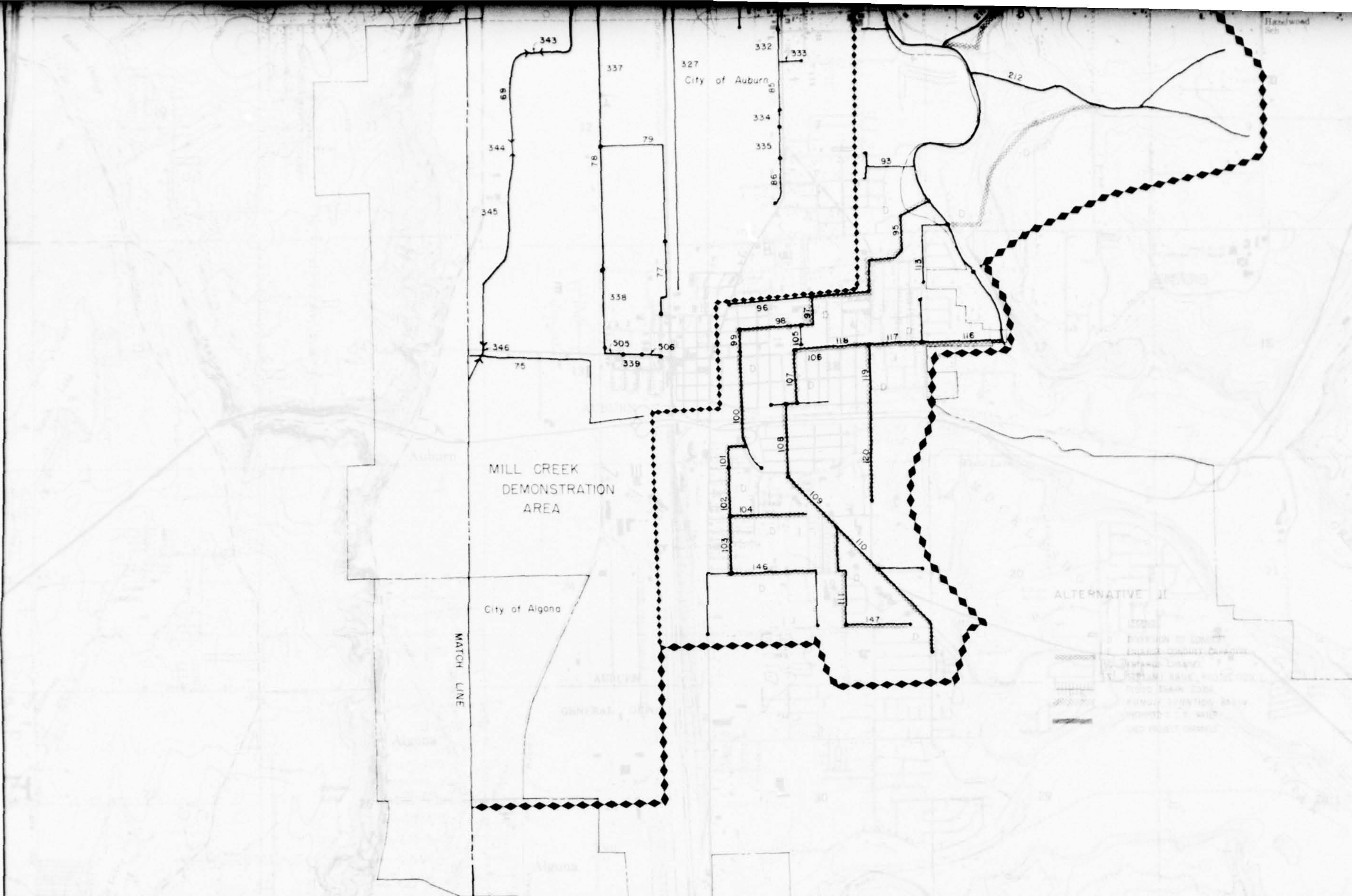
DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2 OF 3



MATCH LINE
City of Kent
City of Auburn



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

MILES

FEET

NO	DESCRIPTION	DATE	APPROVED

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CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 3 OF 3

REGIONAL SUB-BASIN G-6

BLACK RIVER

GENERAL DESCRIPTION

The Black River Sub-Basin is located between the cities of Renton and Kent in the Green River Valley. The western boundary is defined by the lower Green River and the eastern boundary is the highlands drainage divide east of Panther Lake. Mill Creek, a tributary to the Black River, originates near Kent, flows through the valley and joins Garrison and Springbrook Creeks to form the Black River, north of Longacres Racetrack. The Black River discharges into the Green River through the recently constructed P-1 Pump Station at Tukwila. Panther Creek, which originates at Panther Lake, also discharges into the Black River near Longacres. The area lying west of Highway 167 is a relatively flat flood plain. The eastern two-thirds of the sub-basin is in a steep hillside and upland plateau interspersed with several ravines and natural stream channels.

The principal streams, which drain a total area of 27 square miles, are categorized as follows:

Stream	Category	Drainage Area	Discharge
Black River	III	5.0 sq. mi.	Green River
Mill Creek at Kent	III	9.4 sq. mi.	Mill Creek Valley reach
Garrison & Springbrook Creek	III	6.2 sq. mi.	Black River Obrien
Panther Creek	III	2.0 sq. mi.	Black River near Longacres

Present development is predominately agricultural and residential. Urban and industrial land use is concentrated near the cities of Renton and Kent. The lower reaches of streams entering Black River constitute a significant area of wetlands that are indicated as "unused" in the following table of land-use percentages.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	P.S.G.C. Land Use Projection Corridor
Single Family	58	59	59
Multiple Family		1	1
Commercial/Services	3	5	5
Govt. and Educ.		1	1
Industrial	3	30	30
Parks/Dedicated Open Space	2	2	2
Agriculture	25		
Airports, Railyards, Freeways, Highways	1	1	1
Unused Land	7		
Water	1	1	1
Total	100	100	100
Total Impervious Area	20	55	55

Future development trends indicate the continued conversion of agricultural lands to commercial and industrial uses. The municipalities of Renton, Kent and Tukwila have jurisdiction over development of nearly all the flood plain west of SR-167. King County, however, controls the permits for drainage development in the Green River flood-control zone and also have jurisdiction over the major portion of upland areas.

NATURE OF EXISTING DRAINAGE SYSTEM

The Black River Sub-Basin, together with the lower Green River, includes 2700 acres of wetlands and several hundred acres of brushy wildlife habitat. Panther Lake is located in a marshy depression in the uplands and provides habitat for waterfowl. Much of this upland area is poorly drained by natural streams or roadside ditches. These streams converge to form perennial creeks that discharge to the major flood-plain channels. The creeks, such as Mill Creek, have steep gradients and are subjected to severe erosive velocities from urban runoff especially during heavy rainstorms. The P-1 channel will be

aligned along the main course of the existing Black River and eliminate nearly all associated wetlands.

A small portion of the Black River, has been channelized to provide a forebay to the recently constructed Black River drainage pump station. This pumping facility has the capacity to discharge approximately 3000 cfs against flood stages of the Green River to maintain the Black River system at a normal water-surface elevation. The pump station and the channel were constructed by King County and were credited with preventing several thousands of dollars in flood damages during the flood of March, 1972. A fish passage within the drainage structure enables spawning salmon and game fish to migrate upstream and it provides downstream passage for juvenile fish.

DRAINAGE PROBLEMS

Problems were inventoried with use of records of the municipal and county agencies and by field surveys. Most frequent problems are local flooding in flat upland and lowland areas. Frequent flooding and siltation of channels have occured in the City of Kent. Severe erosion of channels and debris accumulation have caused considerable costly flood damage. Greater stormwater volumes and velocities will be produced as the sub-basin transforms from rural/agricultural to urban/industrial use. The main problem with the Black River collection system is that channel P-1 has not been completed and existing stream channels do not have sufficient capacity to transmit greater flood flows to the pump station without overbank flooding.

Hillside drainage systems are mostly open channels which are subject to very high flow velocities. Erosion on steep slopes and sedimentation along flatter channels are common problems. The problem of ponding in the plateau areas is typified at Panther Lake where a small pipe outlet system causes flooding of several acres of pasture annually. Hillside erosion and plateau ponding in the Kent-Mill Creek sub-area have been the subject of at least two other studies and may be considered typical of hillside drainage problems in an urbanizing basin. The mouth of the canyon is constricted by a closed conduit in a commercial sector, while more and more water is being discharged to an already overloaded natural stream from the developing uplands.

Both the 2000 Comprehensive and Corridor Land-Use Plans indicate extensive urbanization of the Black River Sub-Basin. The results of hydrologic analyses indicate no significant difference between the Comprehensive and Corridor Land-Use Plans. Therefore, the drainage alternatives presented herein are applicable to both plans. The existing drainage problems will become more severe because of increases in impervious areas and faster runoff. The total impervious area in this sub-basin with either land use projection, will increase from the existing 20% level to approximately 55% as shown in the table of projected land uses.

Under future land use conditions, nearly all valley channels have insufficient capacity to discharge the 10-year storm runoff without surcharging. It is noteworthy that much of the ponding in the sub-basin occurs in depressions, both man-made and natural, which do not have well-defined drainage system.

The most critical problems within the sub-basin, that of valley ponding, can be alleviated only by a system of drainage channels. The proposed PL-566 East Side Watershed Project is such a channelization scheme. Since completion of the P-1 pump station in 1972, considerable effort has been made to have the balance of the project implemented. The magnitude of cost, together with adverse environmental impacts, and land negotiations have held up the project since it was authorized for construction in 1964. The Department of Fisheries has urged the preservation of coho and chum salmon spawning beds in Mill and Garrison Creeks. No comprehensive drainage plan has been adopted for the hillside and plateau areas. However, the City of Kent has developed some alternatives to improve the Mill Creek drainage system.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

The sponsors of the East Side Green River Watershed Project have adopted the basic PL-566 drainage plan that was authorized by Congress in 1966. The sponsors are the cities of Kent, Renton, Tukwila and Auburn, King County, Green River Flood Control Zone District and King County Soil and Water Conservation District. A draft Environmental Impact Statement will be forthcoming in early 1974. Substantial development within the sub-basin has taken place during the interim period. City and county agencies are permitting limited development of industry, but no major expansion can be permitted until the collection system has been constructed. The Mill Creek study was sponsored by the City of Kent and alternatives for future urban development are being considered in an effort to preserve some of the natural character of this major tributary. Both Renton and Kent have adopted comprehensive planning policies, adherence to which could conserve natural upland areas, lakes and streams to enhance the growth of suburban residential areas without loss of those amenities.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Black River Sub-Basin as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in the development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

The major improvement in the Black River Sub-Basin would be channelization in the valley. These channels coupled with non-restricted hillside drainage systems constitute Alternative Plan I. The basic system would be sized to allow systematic development of the commercial/industrial complex in the valley and residential development on the hillside and the upland plateaus.

Major Features

The SCS East Side Green River Project would be the major feature within the valley. In addition to the existing pump station, the system would include 25 miles of channels. Channels in the valley would extend the full length of the sub-basin from Renton to Kent. These systems would convey storm drainage primarily from industrial and commercial developments. These channels also would intercept hillside drainage, primarily from residential development.

Storm drainage systems within both Renton and Kent would need to be enlarged to accommodate the 10-year storm runoff under future land use. Streambank protection or diversion pipes are prescribed for hillside drainage systems.

Cost

The cost for Alternative Plan I is estimated to be $19,100,000.

ALTERNATIVE PLAN II

General Concept

Hillside drainage-system improvements may be substantially reduced in magnitude and their natural character preserved through establishment of a runoff-control policy. Provisions of this policy were applied throughout the sub-basin, including the valley, to determine resultant flow rates. Holding ponds were specified at possible upland sites to reduce peak-runoff rates to hillside streams. Alternative Plan II incorporates these policies and natural elements, but assumes that a channelization system equivalent to the SCS Watershed Project would be implemented.

Major Features

The channelization system was assumed to be the same as for Alternative Plan I. Required system capacities, however, would be considerably less.

Several holding ponds are incorporated for the upland plateaus. Generally, storage required to reduce outflow rates to 10-20 cfs are 10 acre-feet or less. These ponds would be located in existing depressions or road embankments that already constrict flow.

Diversion drains are specified along Mill Creek and other streams where road right-of-ways can be used for construction. Some streams would still need streambank protection against erosive velocities.

Cost

The cost for this alternative is estimated to be $17,700,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and land use, and with alternative drainage management solutions for the year 2000. The peak flows are given for various locations along the Black River and for the proposed channels as noted.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
P-1 Pump Station	780	2500	900
Main Outfall, Renton	370	380	370
P-10 Channel	60	550	320
P-9 Channel	N/A	680	410
P-1 Channel at Longacres	450	2200	700
P-2 Channel	140	1150	390
P-3 Channel	N/A	400	80
P-1 Channel at Orillia	250	820	310

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
Garrison Creek	200	640	240
P-1 Channel at Kent	300	570	310
Mill Creek at Kent	410	500	260

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternative plans for this sub-basin. This procedure was followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. *The criteria rating total for Alternative Plan I*, which employs channelization, streambank protection, enlarged conduit, pump stations, and diversion channels, was a minus 51 on a scale ranging from positive 108 to negative 108. The total evaluation rating for Alternative Plan II, which employs runoff control, storage, channelization, streambank protection, enlarged conduit, pump stations and diversion, was a minus 27.

Both alternatives received negative ratings for effectiveness, although they both were judged to properly control flood damage. The basic reason for the negative rating for effectiveness was the questionable reliability of the pump station and the amount of maintenance required for both the pump station and the numerous channels. Alternative Plan II received a positive rating for promotion of human values based because it increased the amount of usable land available within the sub-basin and it did not require displacement of people. Alternative Plan I was rated slightly behind Alternative Plan II in human values, primarily because of the extensive channelization necessary in the upper plateaus that might destroy the natural quality of the existing streams. Both alternative plans received negative ratings for environmental factors as it was believed that they would have questionable impacts on wildlife, aquatic life, and natural vegetation. However, Alternative Plan II does appear to promote water quality as well as to assure low-flow conditions. Importantly, both alternative plans require extensive alteration of the natural system. Implementation of either alternative plan is considered to be difficult. While the Soil Conservation Service channelization element within each alternative plan is approved as to funding and authority, the mechanics for imple-

menting this particular project have proven to be extremely difficult. Those portions of both alternative plans that relate to the upland and ravine areas of the sub-basin, require cooperation of more than one jurisdiction and, therefore, could be difficult to accomplish. Both alternative plans received the maximum negative score for resource requirements as they both commit extensive resources, land, capital and energy.

Alternative Plan II, because of runoff control and upper sub-basin storage, does result in a lesser requirement for channelization within the valley floor of the Black River. The savings in cost for system construction are significant because of this storage potential and runoff control. This treatment combination, if it is to be part of the chosen alternative, should be implemented as an early organized effort. Any additional portion of the sub-basin that develops without these combined controls will require more structural treatment than Alternative Plan II can accommodate in the upper sub-basin. This issue should be brought to the attention of all citizens and their local agencies.

Because both alternative plans assume that a project similar to the Soil Conservation Service Plan will be implemented, a major environmental sacrifice will be the loss of the extensive wetlands still present on the valley floor. An economic gain will be realized by valley-floor property owners who will now be able to develop their property to the full allowance of existing or future zoning.

CONCLUSIONS

Neither alternative plan is superior to the other, nor is either alternative plan necessarily desirable in light of the tremendous economic cost of construction and the almost immeasurable loss of the natural environment of the Black River Valley. Alternative Plan II, because it does require runoff control at or near the existing rates for any new development, and because it does provide upland storage, does reduce the cost of the system necessary for the valley floor. This portion of the alternative, if it is to be part of the chosen method of drainage control, does require immediate action.

King County and the cities of Renton and Kent should extend the working agreement that aided in creation of PL-566 for a master drainage plan, incorporating the provisions of Alternative Plan II as they apply to the upland portions and ravine portions of the sub-basin. These agencies then should move to implement and enforce the required runoff controls and acquire rights to the necessary storage areas within their own jurisdictions.

Two basic issues exist; first, the controversial sacrifice of natural wetlands and agricultural area in favor of high-intensity industrial and commercial development and secondly, determination of which local agency or agencies will have jurisdiction and responsibility for

control of urban drainage and related flood-damage problems. The land-use question has been an issue between local governments and the Puget Sound Governmental Conference. The second issue could be resolved by giving King County the responsibility for control of drainage and flood damage within the Black River Sub-Basin.

RUNOFF QUALITY SUMMARY
BLACK RIVER

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
	2000 Comprehensive Land Use						
P-1 Pump Station	I	2500	13	1.4×10^4	.5	1.4	.1
	II	900	13	1.4×10^4	.5	1.4	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

BLACK RIVER

ALTERNATIVES	EFFECTIVENESS SUB TOTAL	Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	HUMAN VALUES SUB TOTAL	Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	ENVIRONMENTAL FACTORS SUB TOTAL	High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	IMPLEMENTATION SUB TOTAL	Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	RESOURCE REQUIREMENTS SUB TOTAL	Energy	Materials	Land	Capital	RATING TOTAL
CRITERIA WEIGHT		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	-8									0								-26										-7							-10					-51
II	-1									+4								-10										-10							-10					-27

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I & II Sub-Basin Black River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
500	Channel	40'	1,050'	3:1	24'	Channel	Existing	(1)
501		No existing channel				Channel	40' width 24' depth 3:1 side slopes 600'	
502		No existing channel				Channel	40' width 18' 3:1 side slopes 3,500'	
503		No existing channel				Channel	40' width 13' depth 3:1 side slopes 2,000'	
504		No existing channel				Channel	4' width 5' depth 3:1 side slopes 3,300'	
505		No existing channel				Channel	40' width 12' depth 3:1 side slopes 1,300'	
506		No existing channel				Channel	12' width 7.5' depth 3:1 side slopes 5,800'	
507		No existing channel				Channel	4' width 7' depth 3:1 side slopes 5,400'	
508		No existing channel				Channel	4' width 7' depth 3:1 side slopes 3,350'	
509		No existing channel				Channel	40' width 12' depth 3:1 side slopes 7,200'	
510		No existing channel				Channel	10' width 12' depth 3:1 side slopes 6,900'	
511		No existing channel				Channel	8' width 8' depth 3:1 side slopes 5,800'	
512		No existing channel				Channel	6' width 8' depth 3:1 side slopes 5,700'	
513		No existing channel				Channel	4' width 8' depth 3:1 side slopes 6,000'	
514		No existing channel				Channel	10' width 11' depth 3:1 side slopes 4,400'	
515		No existing channel				Channel	4' width 6' depth 3:1 side slopes 2,500'	
516		No existing channel				Channel	4' width 6' depth 3:1 side slopes 3,500'	

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I & II   Sub Basin Black River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
517		No existing channel				Channel	10' width 12' depth 3:1 side slopes 2,250'	
518		No existing channel				Channel	10' width 12' depth 3:1 side slopes 2,600'	
519		No existing channel				Channel	6' width 8' depth 3:1 side slopes 4,100'	
520		No existing channel				Channel	6' width 5' depth 3:1 side slopes 1,000'	
521		No existing channel				Channel	4' width 5' depth 3:1 side slopes 2,000'	
522		No existing channel				Channel	4' width 5' depth 3:1 side slopes 3,500'	
523		No existing channel				Channel	6' width 7' depth 3:1 side slopes 4,150'	
524		No existing channel				Channel	4' width 7' depth 3:1 side slopes 1,800'	
525		No existing channel				Channel	4' width 6' depth 3:1 side slopes 2,100'	
526		No existing channel				Channel	4' width 5' depth 3:1 side slopes 2,000'	
527		No existing channel				Channel	4' width 5' depth 3:1 side slopes 1,600'	
528		No existing channel				Channel	8' width 8' depth 3:1 side slopes 2,500'	
529		No existing channel				Channel	8' width 5' depth 3:1 side slopes 5,650'	
530		No existing channel				Channel	4' width 4' depth 3:1 side slopes 1,200'	
531		No existing channel				Channel	4' width 4' depth 3:1 side slopes 2,000'	
532		No existing channel				Channel	6' width 6' depth 3:1 side slopes 5,700'	
533		No existing channel				Channel	4' width 6' depth 3:1 side slopes 2,300'	

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I & II   Sub-Basin Black River

ELEMENT NUMBER	EXISTING FACILITIES TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES TYPE		ESTIMATED CAPITAL COST
534		No existing channel				Channel	4' width 4' depth 3:1 side slopes 1,800'	
535		No existing channel				Channel	4' width 4' depth 3:1 side slopes 2,000'	
536		No existing channel				Channel	4' width 4' depth 3:1 side slopes 2,800'	
537		No existing channel				Channel	4' width 4' depth 3:1 side slopes 1,000'	

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Sub-Total SCS Channel System: $14,000,000
(as per SCS Preliminary EIS for the East Side Watershed Project)

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Black River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
7	Pipe	18"	500'			Parallel Pipe	27"	$24,000
6	Pipe	24"	1,400'			Parallel Pipe	27"	$66,000
5	Channel	4'	2,200'	2:1	4'	Channel	Bank protection	$34,000
9	Pipe	12"	1,000'			Parallel Pipe	30"	$54,000
11	Pipe	18"	2,200'			Parallel Pipe	30"	$119,000
13	Pipe	24"	2,000'			Parallel Pipe	30"	$108,000
12	Pipe	24"	3,600'			Parallel Pipe	36"	$237,000
4	Pipe	60"	4,000'			Parallel Channel	6' width 6' depth 2:1 side slopes	$135,000
20	Channel	3'	3,000'	2:1	3'	Channel	4' width 2' depth Bank protection	$53,000
18	Pipe	48"	1,600'			Parallel Pipe	66"	$216,000
87	Pipe	48"	100'			Parallel Pipe	78" Includes inlet and outlet	$29,000
85	Channel	3'	3,500'	2:1	2'	Channel	4' width 2' depth 2:1 side slopes Bank protection	$62,000
100	Pipe	Two 30"	1,300'			Parallel Pipe	42"	$103,000
101	None					Channel	4' width 4' depth 2:1 side slopes 3,000'	$33,000
19	Channel	3'	3,000'	2:1	4'	Channel	6' width 4' depth 2:1 side slopes	$8,000
21	Channel	3'	1,400'	2:1	3'	Channel	4' width 4' depth 2:1 side slopes	$7,000
25	Channel	4'	2,500'	2:1	3'	Channel	5' width 3' depth 2:1 side slopes Bank protection	$61,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Black River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
28	Channel	2'	1,500'	5:1	2'	Channel	4' width 3' depth 3:1 side slopes	$4,000
27	Pipe	18"	500'			Parallel Pipe	48"	$47,000
26	Channel	3'	3,000'	2:1	4'	Channel	4' width 4' depth 2:1 side slopes Bank protection	$81,000
24	Channel	6'	4,000'	2:1	2'	Channel	7' width 2' depth 2:1 side slopes Bank protection	$95,000
32	Channel	4'	2,500'	2:1	3'	Channel	5' width 3' depth 2:1 side slopes Bank protection	$62,000
37	Channel	5'	6,000'	2:1	2'	Channel	6' width 2' depth 2:1 side slopes Bank protection	$130,000
39	Channel	5'	5,000'	2:1	4'	Channel	6' width 2' depth 2:1 side slopes Bank protection	$108,000
41	Channel	4'	3,000'	2:1	2'	Channel	5' width 2' depth 2:1 side slopes Bank protection	$59,000
42	Channel	4'	2,000'	2:1	2'	Channel	5' width 2' depth 2:1 side slopes Bank protection	$39,000
40	Channel	5'	2,500'	2:1	3'	Channel	6' width 2' depth 2:1 side slopes Bank protection	$54,000
38	Channel	5'	2,500'	2:1	4'	Channel	6' width 4' depth 2:1 side slopes Bank protection	$78,000
36	Channel	6'	2,000'	2:1	4'	Channel	7' width 4' depth 2:1 side slopes Bank protection	$66,000
35	Channel	4'	3,500'	2:1	2'	Channel	5' width 2' depth 2:1 side slopes Bank protection	$69,000
52	Pipe	30"	2,000'			Parallel Pipe	54"	$212,000
53	Pipe	30"	2,000'			Parallel Pipe	60"	$240,000
105	Pipe	18"	1,600'			Parallel Pipe	48"	$149,000
104	Pipe	30"	1,000'			Parallel Pipe	48"	$93,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Black River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
58	Pipe	36"	2,000'			Parallel Pipe	54"	$212,000
68	Pipe	18"	1,400'			Parallel Pipe	30"	$76,000
107	Channel	3'	5,500'	2:1	2'	Channel	4' width 4' depth 2:1 side slopes	$40,000
108	Channel	3'	3,000'	2:1	2'	Channel	4' width 4' depth 2:1 side slopes	$22,000
111	Pipe	18"	3,200'			Parallel Pipe	24"	$134,000
71	Pipe	24"	800'			Parallel Pipe	24"	$34,000
73	Pipe	18"	1,000'			Parallel Pipe	18"	$30,000
72	Channel	6'	1,500'	2:1	6'	Channel	18' width 4' depth Bank protection	$82,000
74E	Channel	10'	5,200'	4:1	4'	Diversion Pipe	48" 6,500'	$605,000
74W		Along Reifen Road on west side				Diversion Pipe	27" 7,000'	$329,000
76	Channel	8'	5,000'	4:1	4'	Diversion Pipe	42" 5,000'	$395,000
77	Channel	6'	1,600'	4:1	4'	Channel	7' width 2' depth 4:1 side slopes Embankment protection	$50,000
81	Pipe	36"	200'			Parallel Pipe	24" Includes inlet and outlet	$12,000
96	Slough	no data				Pump Station	50 cfs	$115,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Sub-Total	$5,071,000
SCS Channel System	$14,000,000
Project Total	$19,071,000
Round To	$19,100,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II   Sub-Basin Black River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
7	Pipe	18"	500'			Parallel Pipe	27"	$24,000
6	Pipe	24"	1,400'			Parallel Pipe	27"	$66,000
5	Channel	4'	2,200'	2:1	4'	Channel	Bank protection	$57,000
9	Pipe	12"	1,000'			Parallel Pipe	30"	$54,000
11	Pipe	18"	2,200'			Parallel Pipe	30"	$119,000
13	Pipe	24"	2,000'			Parallel Pipe	30"	$108,000
12	Pipe	24"	3,600'			Parallel Pipe	36"	$238,000
4	Pipe	60"	4,000'			Parallel Channel	4' width 6' depth 2:1 side slopes	$98,000
20	Channel	3'	3,000'	2:1	3'	Channel	4' width 2' depth 2:1 side slopes Bank protection	$53,000
18	Pipe	48"	1,600'			Parallel Pipe	66"	$216,000
87	Pipe	48"	100'			Parallel Pipe	78" includes inlet and outlet	$29,000
85	Channel	3'	3,500'	2:1	2'	Diversion Pipe	24" 1,500'	$63,000
19	Channel	3'	3,000'	2:1	4'	Channel	6' width 4' depth 2:1 side slopes	$8,000
21	Channel	3'	1,400'	2:1	3'	Channel	4' width 4' depth 2:1 side slopes	$6,000
100	Pipe	Two 30"	1,300'			Parallel Pipe	42"	$103,000
101	None					Channel	4' width 4' depth 2:1 side slopes 3,000'	$33,000
25	Channel	4'	2,500'	2:1	3'	Channel	Bank protection	$36,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II   Sub Basin Black River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
28	Channel	2'	1,500'	5:1	2'	Outlet	24" 40' Earth embankment	$6,000
26	Channel	3'	3,000'	2:1	4'	Channel	4' width 4' depth 2:1 side slopes Bank protection	$81,000
32	Channel	4'	2,500'	2:1	3'	Outlet	24" 40' Earth embankment	$9,000
37	Channel	5'	6,000'	2:1	2'	Diversion Pipe	24" 3,000' 21" 3,000'	$234,000
102	None					Holding Pond	4 AF 1 acre	$9,000
41	Channel	4'	3,000'	2:1	2'	Holding Pond	4 AF 1 acre	$9,000
42	Channel	4'	2,000'	2:1	2'	Holding Pond	4 AF 1 acre	$9,000
105	Pipe	18"	1,600'			Parallel Pipe	48"	$149,000
104	Pipe	30"	1,000'			Parallel Pipe	48"	93,000
58	Pipe	36"	2,000'			Parallel Pipe	54"	$212,000
68	Pipe	18"	1,400'			Parallel Pipe	30"	$76,000
96	Slough	No data				Pump	50 cfs (estimated)	$115,000
111	Pipe	18"	3,200'			Parallel Pipe	24"	$134,000
71	Pipe	24"	800'			Parallel Pipe	24"	$34,000
73	Pipe	18"	1,000'			Parallel Pipe	18"	$30,000
72	Channel	6'	1,500'	2:1	6'	Channel	4' depth Bank protection	$43,000
74W		Along Reifen Road on west side				Pipe	27" 7,000'	$329,000

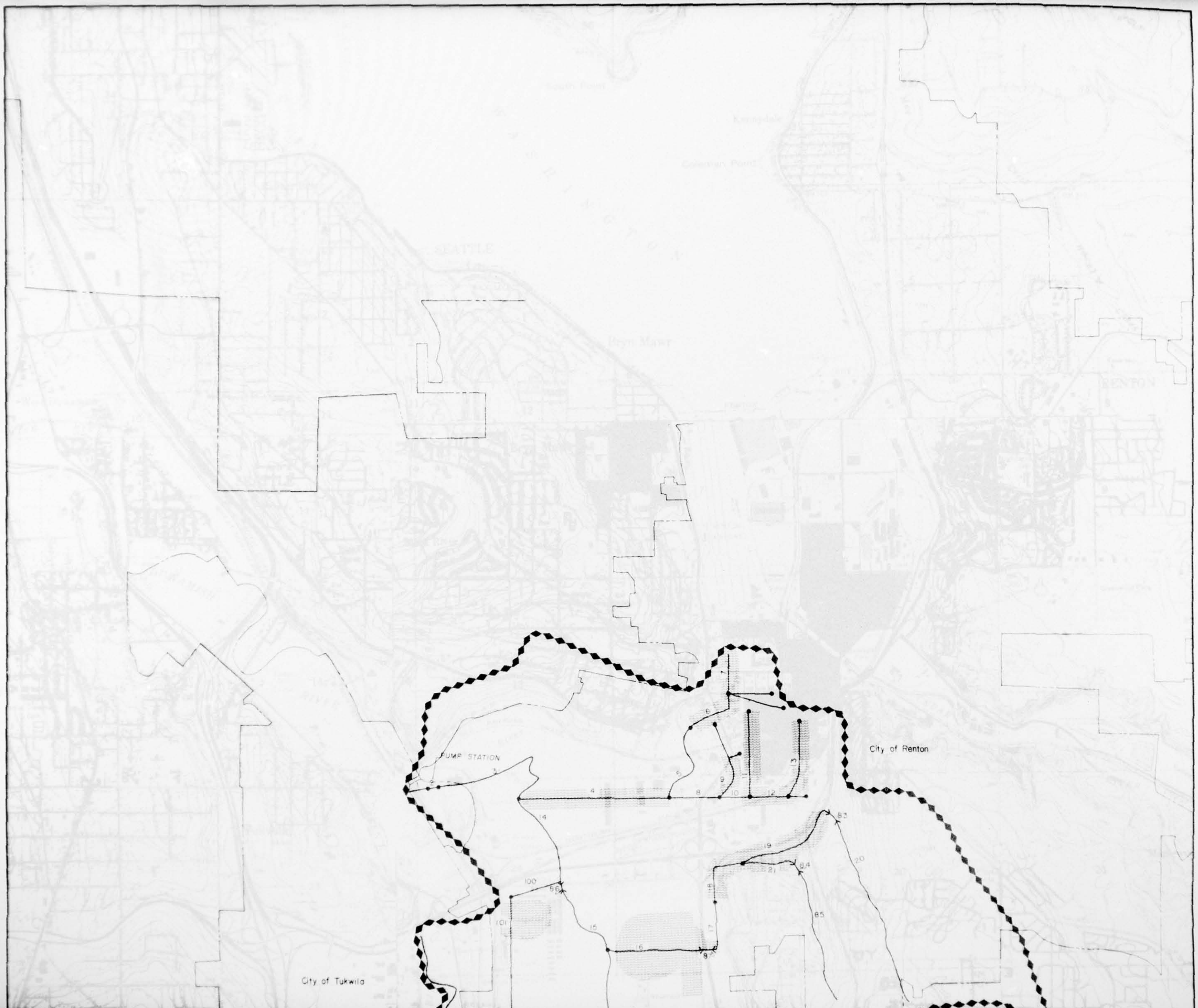
RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Black River

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
74E	Channel	10'	5,200'	4:1	4'	Diversion Pipe	36" 6,500'	$429,000
76	Channel	8'	5,000'	4:1	4'	Diversion Pipe	36" 5,000'	$330,000
91	Channel	2'	5,000'	2:1	2'	Holding Pond	8 AF 4 acres	$30,000
82	Slough	200'	700'		2'	Holding Pond	10 AF 3.2 acres	$25,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Sub Total: $3,697,000
SCS Channel System: $14,000,000
Project Total: $17,697,000
Round to: $17,700,000



City of Renton
PUMP STATION
City of Tukwila

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

BLACK RIVER

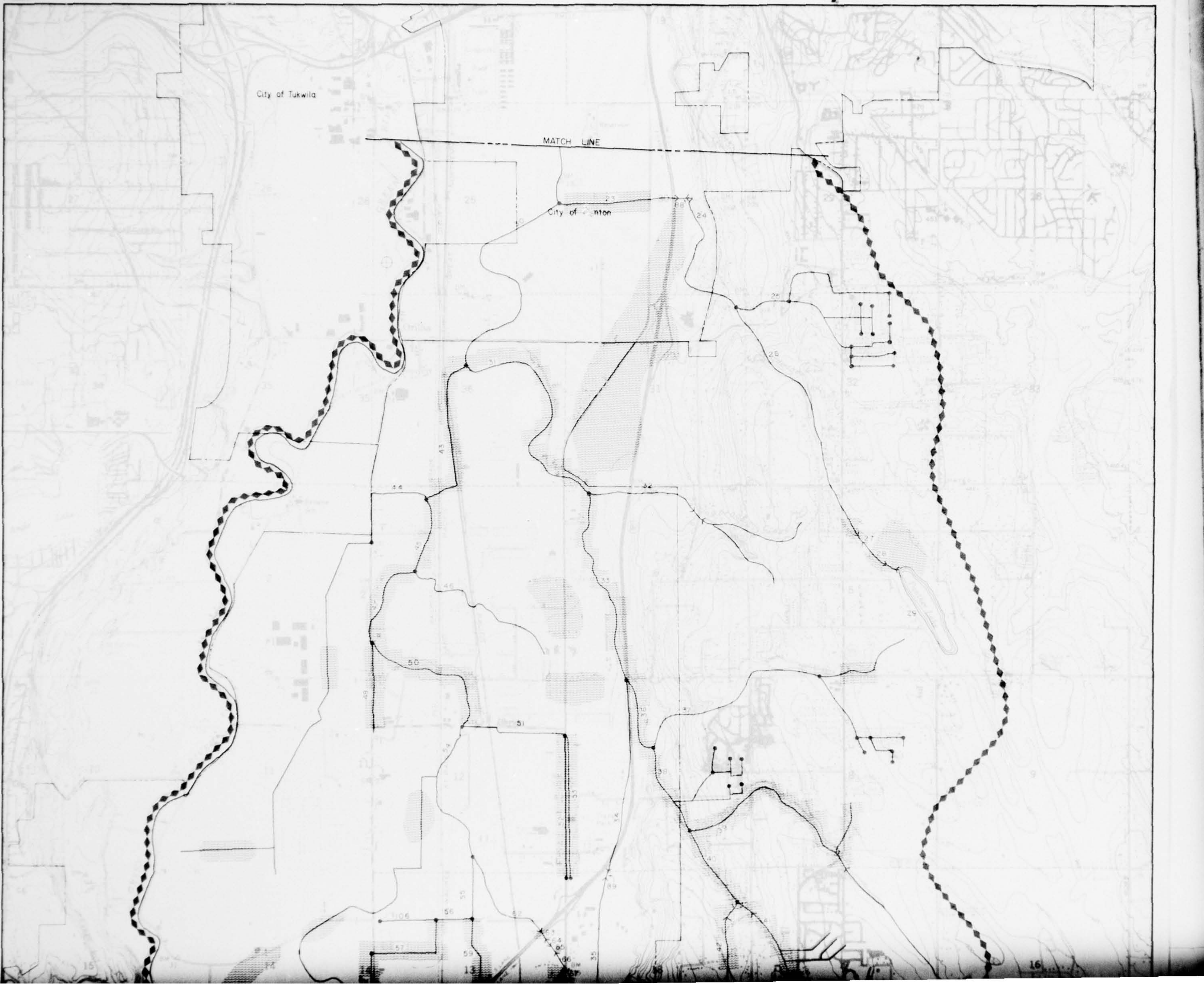
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1 OF 2

2


City of Tukwila
MATCH LINE
City of Renton

LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. 5
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

N

MILES: 1/2, 1/4, 0, 1

FEET: 1000, 500, 0, 4000

NO.	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

BLACK RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
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SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2 OF 2

2

REGIONAL SUB-BASIN G-7

DUWAMISH ESTUARY

GENERAL DESCRIPTION

The Duwamish Estuary Sub-Basin encompasses the highly industrial and urbanized sector of South Seattle that extends from Elliot Bay upstream to the Municipality of Tukwila. It has an area of approximately 25 square miles and includes Longfellow Creek, an area of two square miles, that runs through the West Seattle Golf Course and discharges to the West Waterway near Harbor Island.

The Duwamish River forms the lower reach of the Green River below its confluence with the Black River. The length of the river from Elliot Bay to the mouth of the Black River is 10.8 miles. The lower five miles of waterway is a dredged ship channel that extends upstream to the southern end of Boeing Field. The major flood flows to this river are discharged from the Green and Black rivers. The watershed on either side of the river is intensely developed and rises steeply to north-south ridges between Lake Washington and Lower Puget Sound drainage basins. Storm-drainage channels are fairly short, from one to two miles long, and runoff to the river is very rapid.

Present development consists primarily of residential, industrial and commercial uses. Land-use categories for existing conditions, 2000 Comprehensive and 2000 Corridor Plans are estimated by percentages in the following table.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	51	38	37
Multiple Family	3	5	5
Commercial/Services	10	5	20
Govt. and Educ.	2	2	2
Industrial	25	40	30
Parks/Dedicated Open Space	2		
Agriculture		5	1

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Airports, Railyards, Freeways, Highways	2	5	5
Unused Land	5		
Total	100	100	100
Total Impervious Area	60	65	70

Future land-use estimates indicate significant increase in industrial and manufacturing development, with some loss of single-family development. There is seven percent of open and undeveloped land in the sub-basin presently and this will be preserved essentially in both land-use plans. The sub-basin lies within the jurisdictions of Seattle, Tukwila and King County.

NATURE OF EXISTING DRAINAGE SYSTEM

The Duwamish Waterway is the primary transportation link for Seattle-based industry with ports throughout the world. Ships use the channel even during high flood stages. Therefore, the channel has been widened and deepened to accommodate barges and ocean-going vessels. The channel also is the gateway to the Green River for migrating salmon, steelhead and other fish having both commercial and sport value. The upper reach of the waterway, from Boeing Field to Tukwila, has been channelized and adjacent development is protected from flooding by dikes and revetment along the course of the river.

DRAINAGE PROBLEMS

Major floods have occured along the upper reach of the river in spite of the fact that the channel has extensive flood protection and that Green River flood flows are controlled at Howard Hanson Dam. Flooding has occured during high-water stages in Allentown and adjacent industrial development due to inadequate storm drain outlets. Flooding also has occured in the lower reach of Longfellow Creek near Bethlehem Steel Company. In addition to high peak flows from runoff within Longfellow Creek basin, debris often clogs storm drain culverts and bridges to cause local flooding of property and homes. The City of Seattle, King County, the Corps of Engineers and private individuals provided specific information about flood problems and costs.

Future problems can be deduced from the history of problems under existing conditions. Flood flows from the Green and Black river basins can be expected to increase. Although flows are normally limited to approximately 9,000 cfs at Auburn, it is certain that a maximum legal discharge of 12,000 cfs at Auburn, combined with runoff from

tributary areas below Auburn and a maximum discharge of 3,000 cfs from the Black River pump station would exceed the capacity of the existing Duwamish River channel in Duwamish Estuary, at high tide conditions. If development of tributary areas takes place as indicated in future land use plans for Green River, the flood problems will be increased even more. Development within the Duwamish Estuary Sub-Basin will not increase flood flows in the river significantly. Local flooding however, would be worsened due to increased runoff from developed areas and higher stages within the river that would not permit gravity discharge from tributary areas.

Both the 2000 Comprehensive and Corridor Land-Use Plans indicate that further urbanization of the Duwamish Estuary would use up all land and would leave no dedicated parks or open space. The existing drainage problems will become more severe because of increases in impervious areas and pasture runoff. The total impervious area under the 2000 Comprehensive Land-Use Plan will increase from the existing 60% to 65% and in the 2000 Corridor Land-Use Plan will increase to a level of 70% as shown by the table of projected land uses.

The results of hydrologic analysis indicate a slight difference between the Comprehensive and Corridor Plans; however, the drainage alternatives required similar system improvements. Some systems under the 2000 Corridor Plan would be slightly larger than under the 2000 Comprehensive Plan.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

Presently, the two agencies that have urban drainage planning authority in the Duwamish Estuary Sub-Basin are King County and the City of Seattle. There are two current plans for improving the Duwamish River flood control. The Green River Watershed Project by the Soil Conservation Service was published in 1965. Currently, the Preliminary Draft Environmental Impact Statement for this project is being reviewed by its various sponsoring agencies which are the cities of Kent, Renton, Tukwila and Auburn, Green River Flood Control District, King County Soil and Water Conservation District, and King County.

Current plans by the Corps of Engineers to increase channel capacity of the Duwamish River are being reviewed by several public agencies to insure that the project meets mutually acceptable goals and objectives of all planning bodies. The City of Seattle also has long-range plans to preserve Longfellow Creek as an open stream. Construction already has been initiated on an 11-dam detention project within the West Seattle Golf Course. The City's long-range plan for storm drainage development and street improvements will affect runoff characteristics considerably.

Current public attention has been focused upon storm drainage problems within Longfellow, Puget Ridge and Duwamish sub-areas. Citizen sub-committees have been formed to represent the people's interest. Generally the residents along Longfellow Creek want to retain the natural character of the existing creek. They are protesting the increased use of it as a storm drainage facility for paved areas, which increases surface runoff and contaminates the water with oil and grease. Remnants of other streams through the Duwamish sub-basin which already have been transformed into storm-drainage channels would be considered desirable amenities to the community. The City of Seattle has studied a plan of improvements for Longfellow Creek which would add several detention ponds along the recently completed Genesee Street dam. Relatively few trunk storm-drainage facilities exist throughout the sub-basin and, as street improvements are made, opportunities may be available to intercept this runoff and discharge it directly to the Duwamish River. Burlington Northern is currently constructing an interceptor drain above Allentown that will relieve some of the drainage problems in that community. Other industries have constructed pump drainage facilities, dikes and other protective works.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Duwamish Estuary Sub-Basin, as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions provided in development of alternative plans for drainage control as described below.

Two major plans were studied for solving the Duwamish Estuary drainage problem. The first enlarges channels and culverts as needed, and the second enlarges channels and culverts and provides diversions together with runoff control. The description of these two alternative plans follows.

ALTERNATIVE PLAN I

General Concept

This alternative considers traditional solutions to existing and anticipated flooding problems within the sub-basin. Where culverts or storm drains have inadequate capacity, they are enlarged. No diversions or proposed trunk lines are considered. The systems would alleviate problems of flooding along the trunk drainage alignment but would not resolve problems such as ponding which occurs along laterals and streets that were not modeled.

Major Features

The Longfellow Creek drainage system presently consists of open channels and culverts, nearly all of which would need to be enlarged under future land use conditions. This sytem will continue to be open and to be the only receiving stream for lateral storm-drainage systems as the sub-basin develops.

Drainage systems along the Duwamish are generally affected by small hydraulic gradients associated with high-tide and flood-flow conditions. Several major trunk drains would need substantial enlargement. Much of the intensely developed area east of the river and Interstate 5 would be expected to drain to trunk systems, but were not defined for this study.

Cost

The total estimated capital cost for making all the required enlargements and protective works under this alternative is $2,300,000.

All systems proposed in this alternative are gravity drains and would have only minimal operation costs. Maintenance would include removal of debris and sediment from debris and catch basins.

The City of Seattle has completed construction of the Genesee Street dam and holding pond and the cost estimate stated above for Alternative Plan I does not include any additional cost at this facility. This holding pond will reduce capital costs for additional downstream enlargements by approximately $360,000. The existing conduit through the Bethlehem Steel plant will be abandoned and a new conduit will carry the entire flow of Longfellow Creek.

These improvements reflect the requirements for the 2000 Comprehensive land use plan. Approximately 20 elements would need to be slightly increased in size for the 2000 Corridor land use plan if it became a reality. The additional capital costs that would be required for enlarging these elements would be approximately $200,000.

ALTERNATIVE PLAN II

General Concept

The principal consideration in this alternative plan is to limit peak discharges under future land use conditions to 25% greater than that experienced under existing land use. This would be accomplished by on-site runoff controls. Unfortunately, much of the existing land area within the sub-basin already has been highly developed and approaches the levels set forth in the 2000 Comprehensive plan. Nevertheless, peak flows would be reduced somewhat in comparison to Alternative Plan I and more of the natural stream elements would be preserved.

Major Features

Trunk drainage system alignments and type of improvements are similar to those discussed under Alternative Plan I except for Longfellow Creek. The system proposed under this plan would incorporate a diversion conduit along Delridge Way to intercept most of the runoff from the east slope and discharge into the Genesee Street pond. It is recommended that the channels along Longfellow Creek be maintained in their natural state.

Cost

The total cost estimate for capital improvements for Alternative Plan II is $2,900,000. Significant reductions in costs would be realized in the Longfellow Creek sub-area by runoff control and set-back restrictions. However, the diversion trunk along Delridge Way makes the total cost of the alternative greater than that of Alternative Plan I.

Runoff control will significantly reduce enlargements of systems and costs in other major systems along the Duwamish River as reflected in the cost estimates.

Operation and maintenance requirements of drainage systems would be somewhat reduced as compared to Alternative Plan I. Reduction of runoff would also result in less sediment and debris accumulation.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and land use and with alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

	Comprehensive Land Use		Corridor Land Use	Comprehensive & Corridor Land Use
Location	Existing Facilities	Alternative Plan I	Alternative Plan I	Alternative Plan II
Longfellow Creek North of Spokane Street				
a) with Genesee Street dam	230	420	420	---
b) without Genesee Street dam	---	670	820	620

Location	Comprehensive Land Use Existing Facilities*	Comprehensive Land Use Alternative Plan I	Corridor Land Use Alternative Plan I	Comprehensive & Corridor Land Use Alternative Plan II
Longfellow Creek Above Genesee	190	580	700	520
Trunk drain along Idaho Street	140	160	170	140
W. Marginal Way Outfall	20	20	90	20
Highland Park & W. Marginal W. Outfall	130	180	180	180
Outfall at Orchard Street	20	50	40	30
Outfall at 92nd Street	40	400	440	360
Outfall at 96th Street	220	230	240	220
Outfall at Pacific Hwy. Crossing	110	110	110	110

* Peak discharge may be limited by existing system capacity.

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge applicability of the suggested alternatives for this sub-basin. This procedure was followed throughout the RIBCO Study for developing alternative plans of the various regional sub-basin. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements.

The various structural solutions were checked against the appropriate criteria. The various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating for Alternative Plan I for both the Comprehensive and Corridor land use, which enlarges channels and culverts, was a minus 4 out of a possible range from a positive total of 108 and a negative total of 108. The total evaluation rating for Alternative Plan II, which employs the enlargement of channels and culverts, construction of diversions and runoff control, was a 0.

Both alternative plans were judged to be effective in controlling drainage. Both plans involved certain sacrifices of human values and human uses of the plans once they were built. Environmentally, both alternatives have a relatively low rating. Alternative Plan II receives a slightly lower rating because of the construction disruption caused by building of the diversions along Delridge Way. Neither alternative is part of present planning of any of the involved agencies, however, because of the independence of the concerned streams little cooperation is required between Seattle and King County to realize this plan. Both of the alternative plans involve commitments of the use and management of natural resources because they rely upon certain structural treatments for all or part of their solution. Therefore, neither alternative can be said to be clearly superior to the other in this concern.

In Alternative Plan II, the diversion along Delridge Way would provide for maintaining the natural condition of Longfellow Creek. Alternative Plan II also relies on control of runoff from future land development. This treatment, if it is to be part of the chosen alternative, should be implemented as an early organized effort. Any portion of the sub-basin that develops without these controls will require more structural treatment than Alternative Plan II can accommodate. This issue should be brought to the attention of all citizens and their local agencies.

CONCLUSIONS

Neither alternative is superior to the other in the streams that feed directly into the Duwamish waterway; however, Alternative Plan II is clearly superior to Alternative Plan I along Longfellow Creek for Alternative Plan II will preserve the natural open stream of Longfellow Creek. However, Alternative Plan II does require immediate action to protect and preserve the natural values. As pointed out above, this action would require runoff control at or near existing rates for any new development.

King County and the City of Seattle should establish a master drainage plan that incorporates the conditions of Alternative Plan II. Both agencies should then move to implement and enforce the required runoff controls within their own jurisdiction.

RUNOFF QUALITY SUMMARY
DUWAMISH ESTUARY

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW* BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
	2000 Comprehensive Land Use						
Longfellow Creek	I & II	420	30	2.2×10^5	.9	2.5	.2
Slip No. 1	I & II	390	18	1.8×10^5	.6	1.8	.2
Idaho Street	I	160	11	1.5×10^5	.3	1.0	.2
	II	140	11	1.5×10^5	.3	1.0	.2
Highland Park	I & II	180	8	1.0×10^5	.2	1.0	.1
92nd Street	I	400	17	1.3×10^5	.7	1.9	.8
	II	360	17	1.3×10^5	.7	1.9	.8
Pacific Highway	I & II	110	85	1.7×10^5	.1	.6	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

DUWAMISH ESTUARY

ALTERNATIVES	EFFECTIVENESS SUB TOTAL	Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	HUMAN VALUES SUB TOTAL	Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	ENVIRONMENTAL FACTORS SUB TOTAL	High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	IMPLEMENTATION SUB TOTAL	Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	RESOURCE REQUIREMENTS SUB TOTAL	Energy	Materials	Land	Capital	RATING TOTAL
		CRITERIA WEIGHT									CRITERIA WEIGHT								CRITERIA WEIGHT										CRITERIA WEIGHT							CRITERIAWEIGHT				
		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I Corr.	+10									+1								-4										-3							-8					-4
I Comp.	+10									+1								-4										-3							-8					-4
II	+12									+1								-6										-1							-6					0

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Duwamish Estuary

ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
2	Pipe	72"	150'			Parallel Pipe	42" Includes inlet and outlet	$19,000
3	Pipe	One 48" and one 30"	350'			Parallel Pipe	78" Includes inlet and outlet	$70,000
4	Pipe	42"	1,100'			Parallel Pipe	90"	$213,000
5	Channel	10'	1,000'	2:1	3'	Channel	12' width 4' depth 2:1 side slopes	$8,000
7	Channel	8'	4,000'	2:1	3'	Channel	16' width 4' depth 2:1 side slopes Streambank protection	$230,000
61	Pipe	48"	100'			Parallel Pipe	60" Includes inlet and outlet	$22,000
62	Channel	6'	1,300'	2:1	4'	Channel	12' width 4' depth 2:1 side slopes Streambank protection	$65,000
8	Pipe	48"	100'			Parallel Pipe	78" Includes inlet and outlet	$29,000
9	Channel	5'	2,000'	1:1	3'	Channel	10' width 4' depth 2:1 side slopes	$20,000
64	Channel	5'	1,100'	2:1	3'	Channel	8' width 4' depth 2:1 side slopes	$9,000
66	Channel	5'	800'	2:1	3'	Channel	8' width 4' depth 2:1 side slopes Streambank protection	$42,000
10	Pipe	36"	100'			Parallel Pipe	60" Includes inlet and outlet	$22,000
11	Channel	4'	400'	2:1	3'	Channel	6' width 4' depth 2:1 side slopes Streambank protection	$16,000
12	Pipe	30"	100'			Parallel Pipe	54" Includes inlet and outlet	$19,000
13	Pipe	36"	700'			Parallel Pipe	36" Includes inlet and outlet	$52,000
14	Channel	4'	500'	2:1	3'	Channel	6' width 4' depth 2:1 side slopes Streambank protection	$17,000
15	Pipe	36"	100'			Parallel Pipe	54"	$19,000

AD-A042 167 KCM-WRE/YTO SEATTLE WASH F/G 8/8
ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)
DEC 74 DACW67-73-C-0022

UNCLASSIFIED NL

3 OF 4
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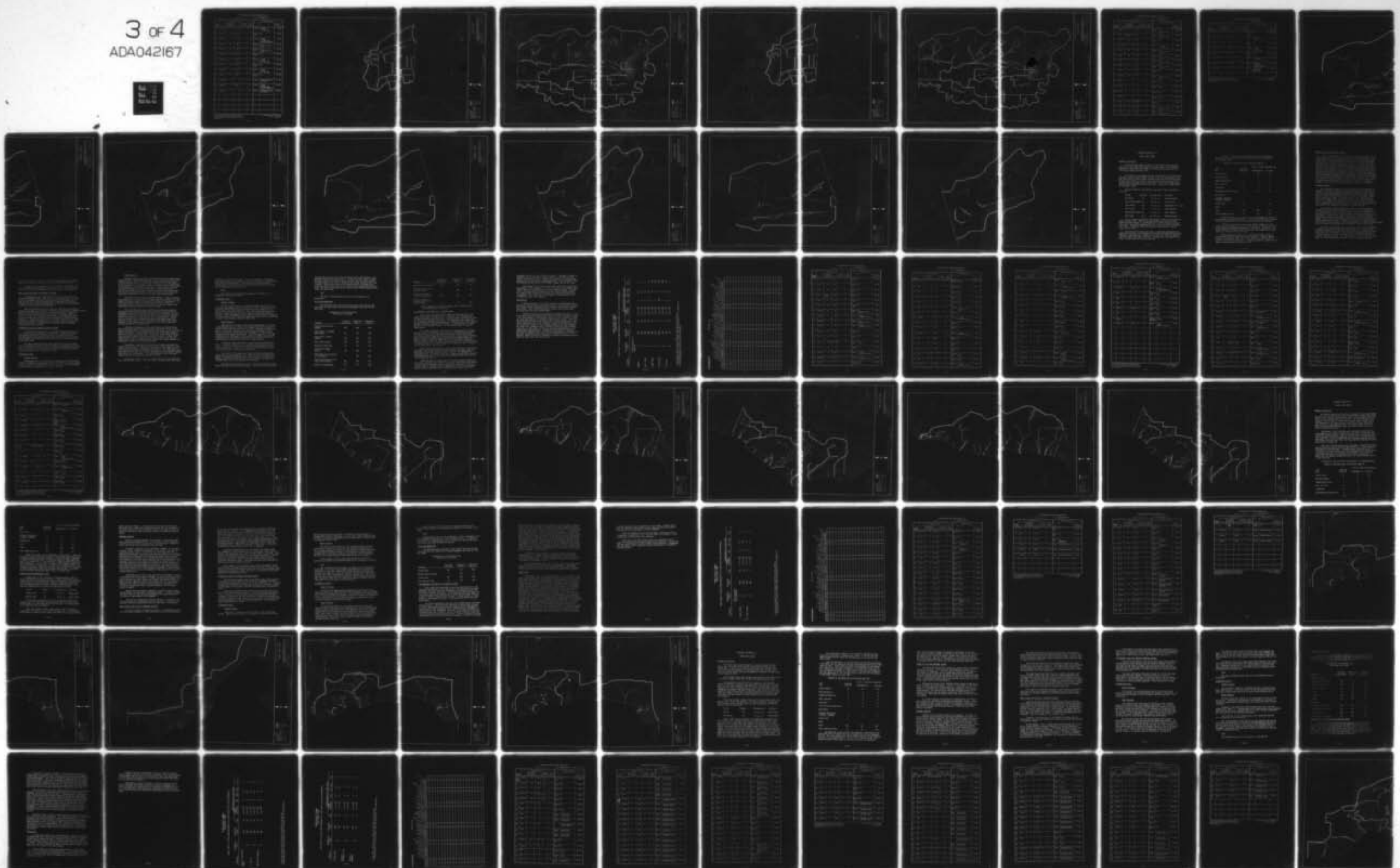


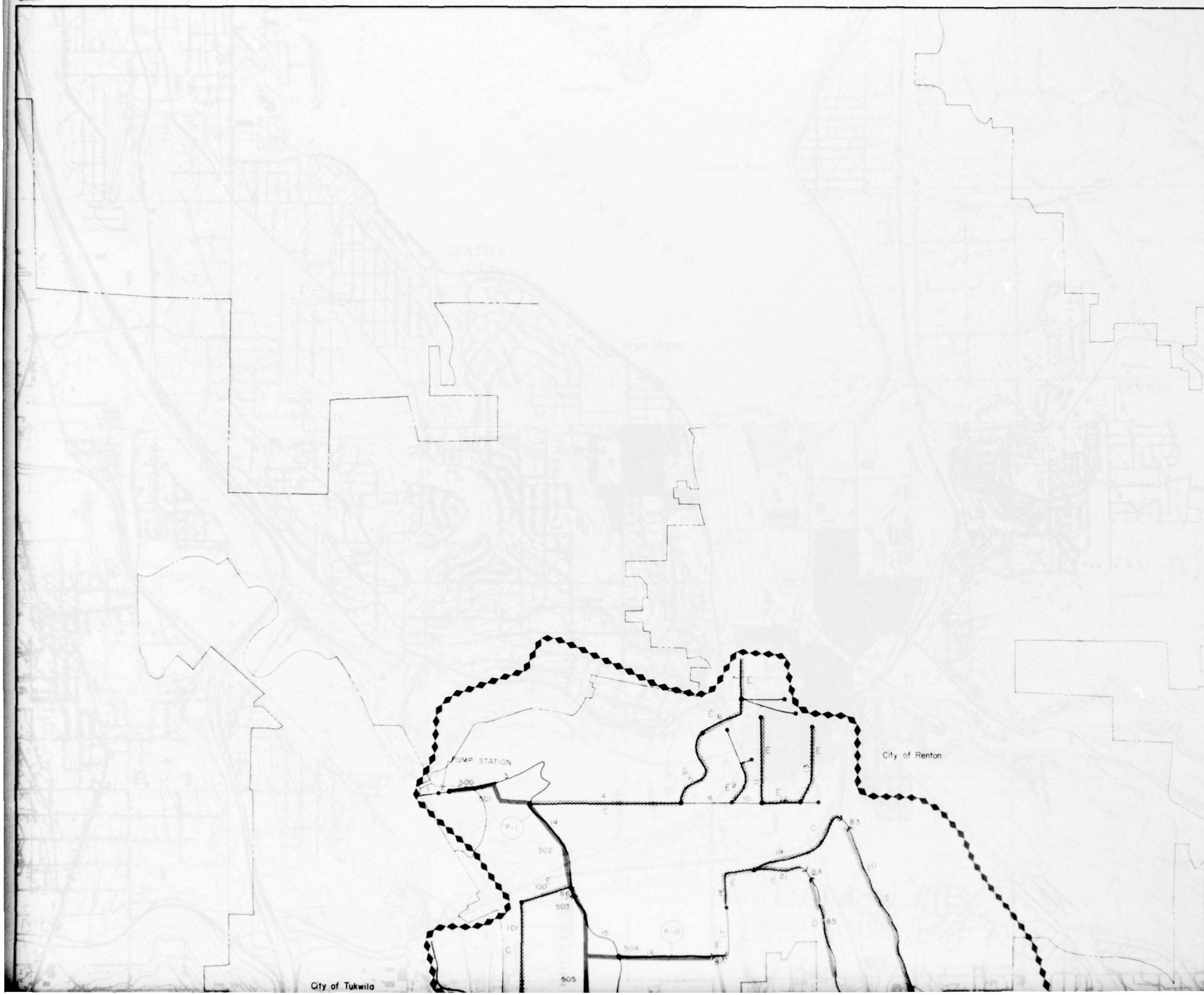
RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Duwamish Estuary

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
16	Channel	4'	1,700'	2:1	3'	Channel	6' width 4' depth 2:1 side slopes	$12,000
19	Pipe	36"	1,000'			Parallel Pipe	36"	$66,000
21	Channel	4'	700'	1:1	4'	Channel	4' width 4' depth 2:1 side slopes Streambank protection	$33,000
27	Pipe	24"	250'			Parallel Pipe	54" Includes inlet and outlet	$35,000
68	Pipe	36"	400'			Parallel Pipe	54" Includes inlet and outlet	$51,000
29	Pipe	18"	4,100'			Parallel Pipe	60"	$492,000
30	Channel	3'	2,100'	1:1	2'	Channel	4' width 3' depth 2:1 side slopes	$12,000
32	Pipe	30"	3,200'			Parallel Pipe	42"	$253,000
33	Channel	3'	1,100'	1:1	2'	Channel	8' width 5' depth 2:1 side slopes	$23,000
34	Pipe	30"	1,300'			Parallel Pipe	48"	$121,000
35	Channel	3'		2:1	3'	Channel	Streambank protection Lower 3,000'	$101,000
46	Channel	6'	4,600'	1:1	3'	Channel	8' width 3' depth 2:1 side slopes Streambank protection	$172,000
36	Channel	6'		2:1	4'	Channel	Streambank protection Lower 3,000'	$66,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $2,309,000
Round To: $2,300,000



City of Renton
PUMP STATION
City of Tukwila

LEGEND

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FEET: 1000 500 0 4000

NO.	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

BLACK RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1 OF 2

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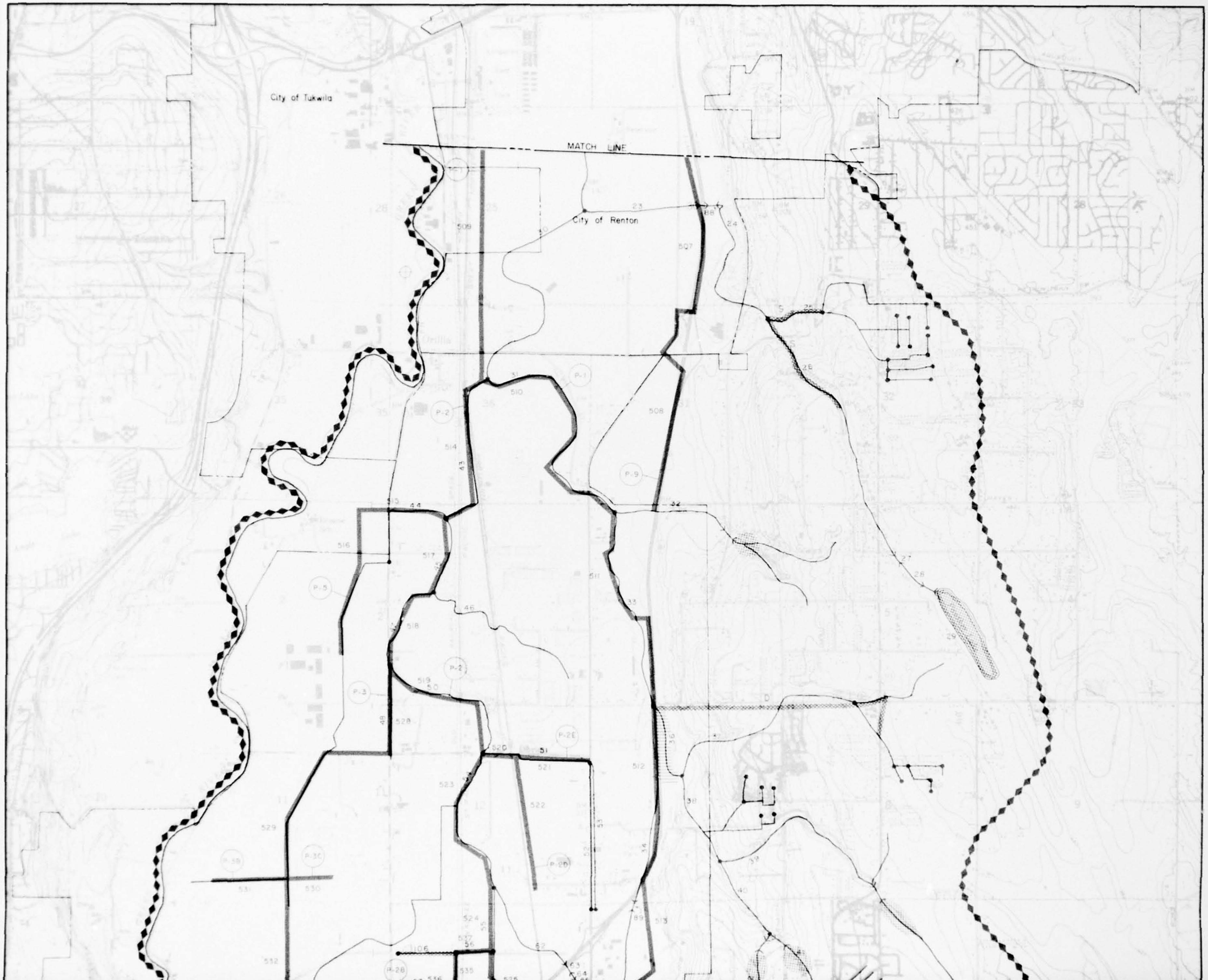
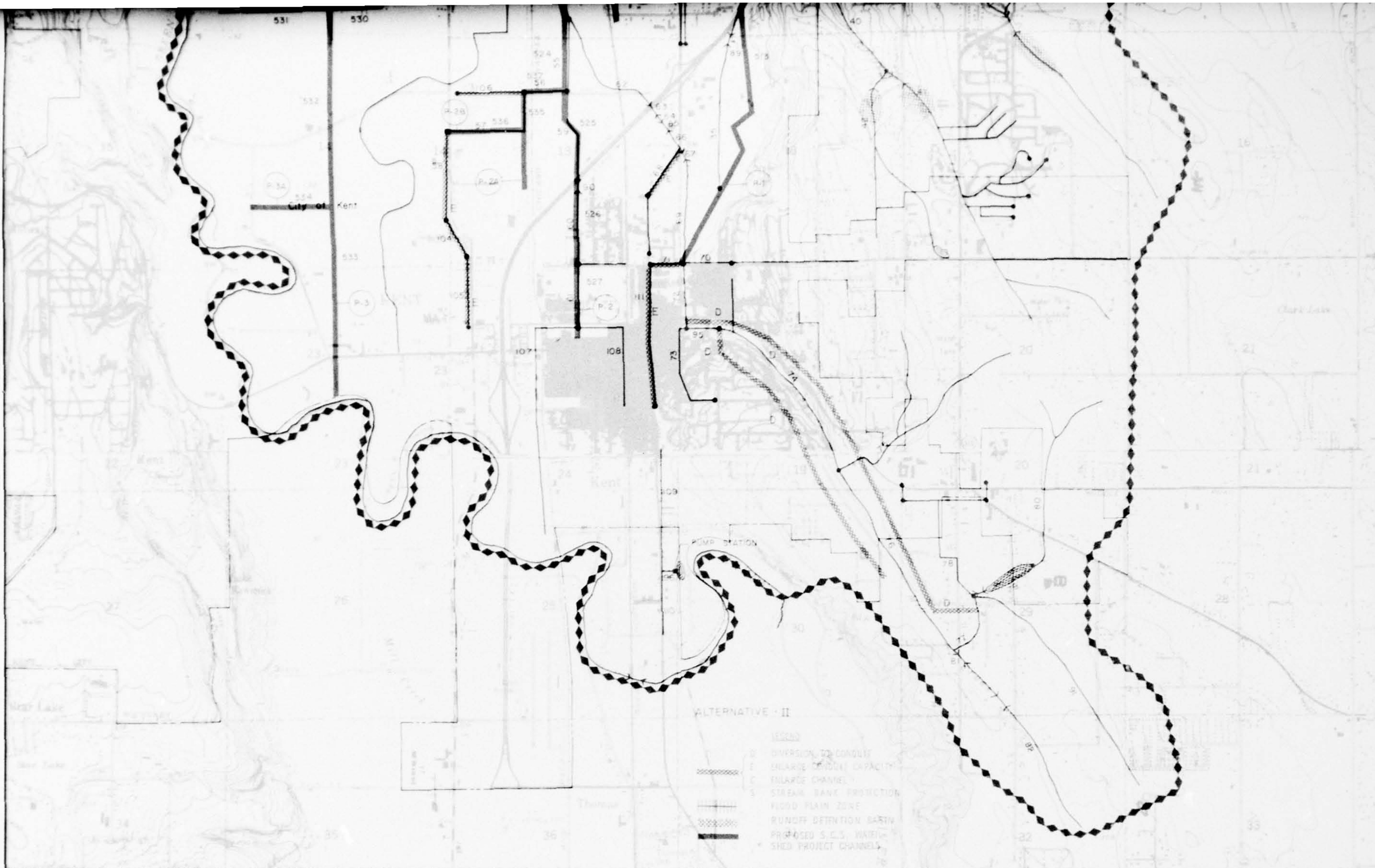


City of Tukwila
MATCH LINE
City of Renton



LEGEND

- SUB-BASIN BOUNDARY
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- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG.
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

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FEET 1000 500 0 4000

NO.	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

BLACK RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2c OF 2

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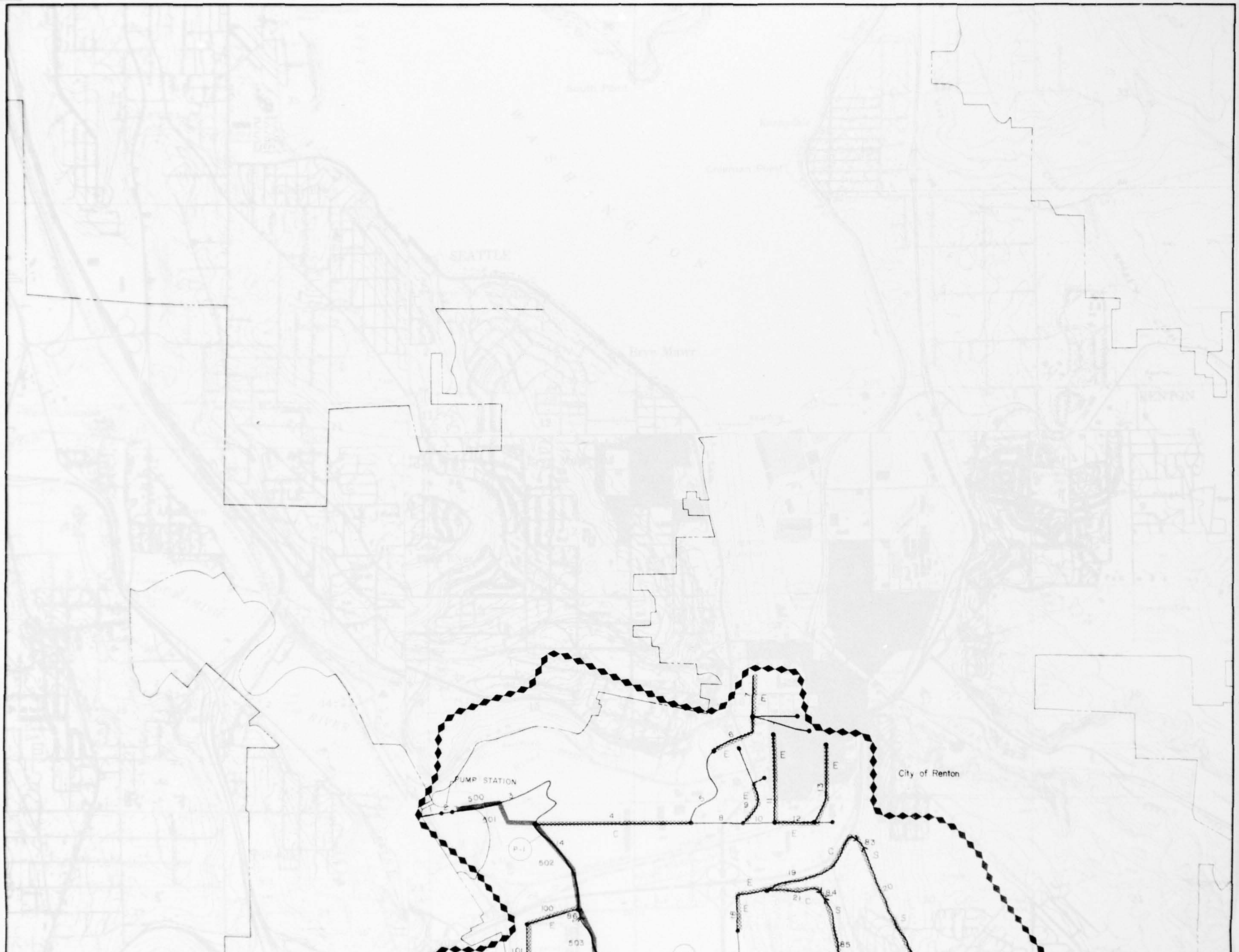
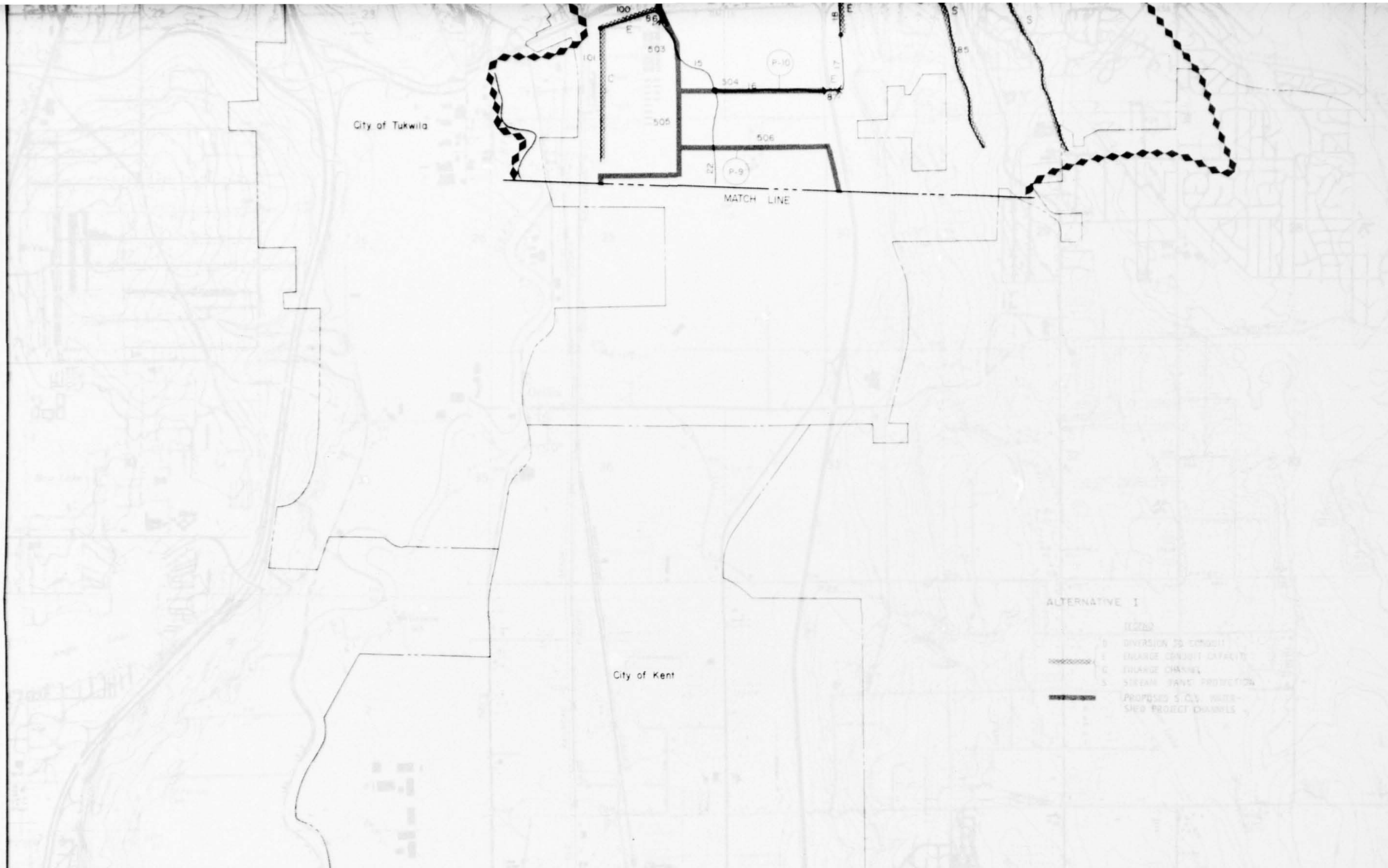


City of Renton
PUMP STATION
SEATTLE



LEGEND

SUB-BASIN BOUNDARY
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NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

BLACK RIVER

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1 OF 2

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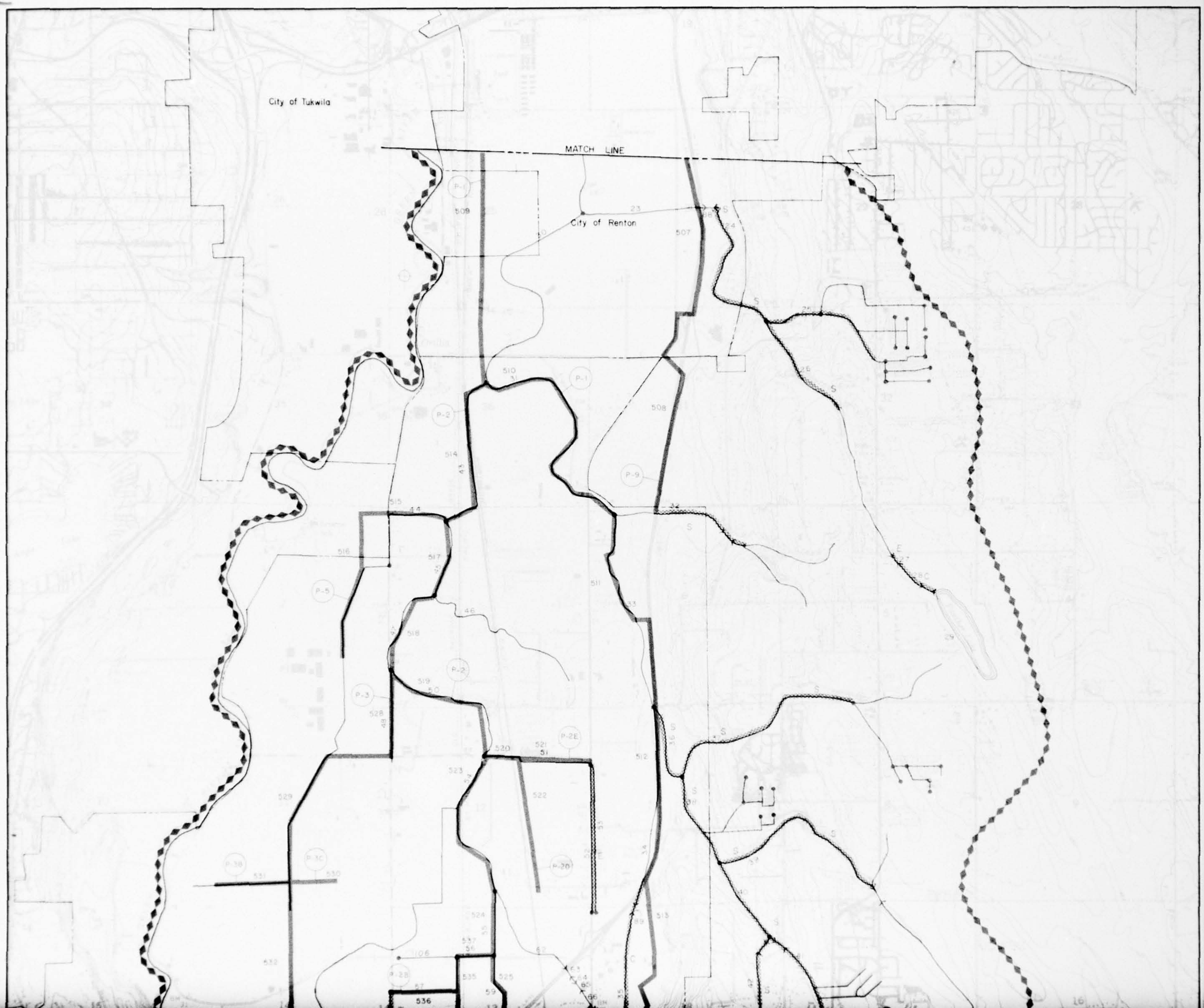

City of Tukwila
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City of Renton
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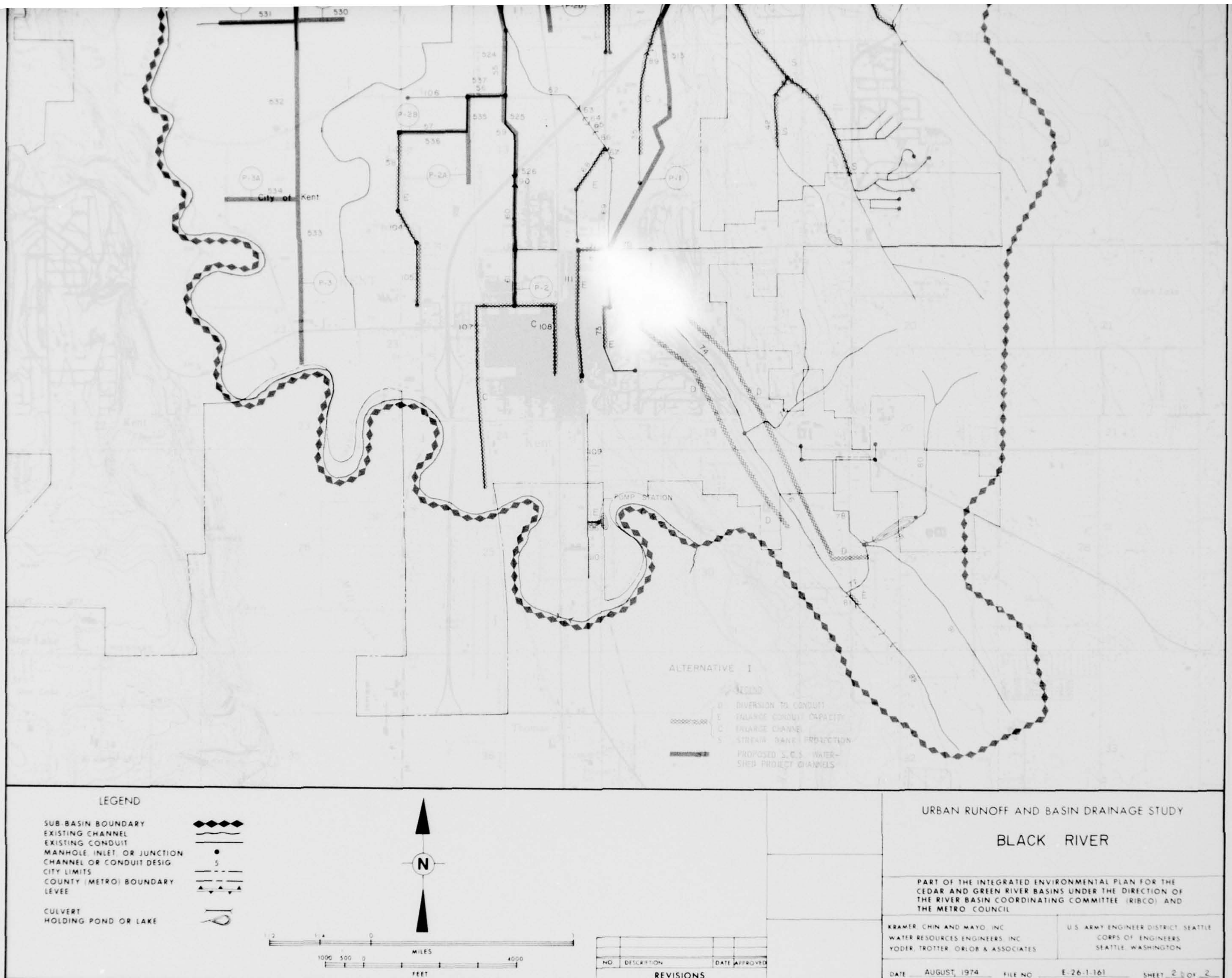
City of Kent
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APPROVED
REVISIONS
URBAN RUNOFF AND BASIN DRAINAGE STUDY
BLACK RIVER
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
DATE AUGUST, 1974
FILE NO E-26-1-161
SHEET 2 b OF 2

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Duwamish Estuary

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
2	Pipe	72"	150'			Parallel Pipe	42" Includes inlet and outlet	$19,000
3	Pipe	One 48" and one 30"	350'			Parallel Pipe	78" Includes inlet and outlet	$70,000
4	Pipe	42"	1,100'			Parallel Pipe	90"	$213,000
5	Channel	10'	1,000'	2:1	3'	Channel	12' width 4' depth 2:1 side slopes	$8,000
61	Pipe	48"	100'			Parallel Pipe	42" Includes inlet and outlet	$15,000
8	Pipe	48"	100'			Parallel Pipe	60" Includes inlet and outlet	$22,000
10	Pipe	32"	100'			Parallel Pipe	48" Includes inlet and outlet	$17,000
12	Pipe	30"	100'			Parallel Pipe	48" Includes inlet and outlet	$17,000
13	Pipe	36"	700'			Parallel Pipe	36"	$46,000
15	Pipe	36"	100'			Parallel Pipe	42" Includes inlet and outlet	$15,000
17A	None					Diversion Pipe	27" 1,500'	$71,000
16A	None					Diversion Pipe	36" 4,000'	$264,000
9A, 8A	None					Diversion Pipe	48" 5,700'	$530,000
7A	None					Diversion Pipe	42" 3,300'	$261,000
19	Pipe	36"	1,000'			Parallel Pipe	36"	$66,000
27	Pipe	24"	250'			Parallel Pipe	54" Includes inlet and outlet	$35,000
68	Pipe	36"	400'			Parallel Pipe	54" Includes inlet and outlet	$51,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

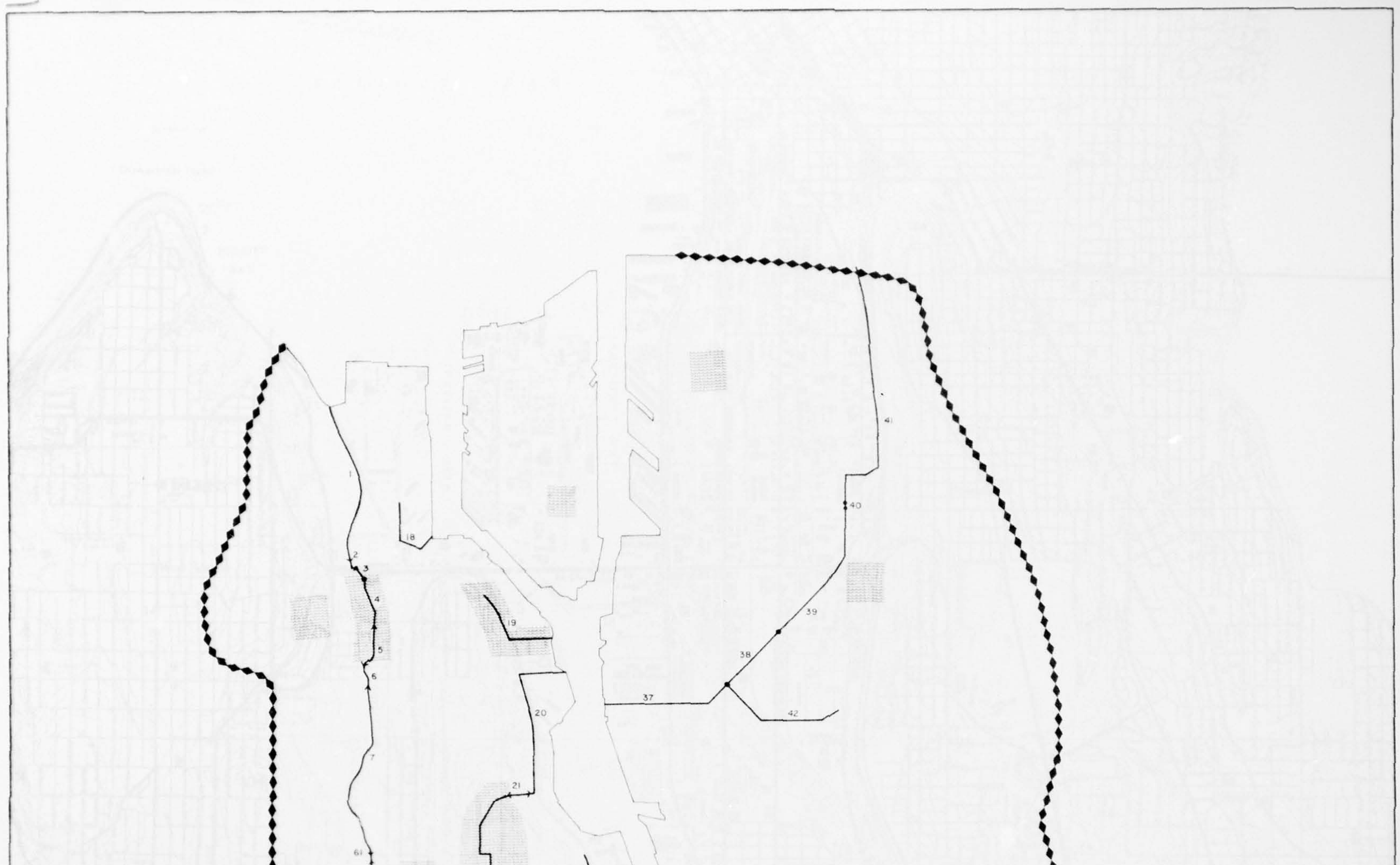
Alternative II Sub Basin Duwamish Estuary

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
29	Pipe	18"	4,100'			Parallel Pipe	60"	$492,000
30	Channel	3'	2,100'	1:1	2'	Channel	4' width 3' depth 2:1 side slopes	$12,000
32	Pipe	30"	3,200'			Parallel Pipe	27"	$150,000
33	Channel	3'	1,100'	1:1	2'	Channel	6' width 5' depth 2:1 side slopes	$20,000
34	Pipe	30"	1,300'			Parallel Pipe	48"	$121,000
35	Channel	3'		2:1	3'	Channel	Streambank protection Lower 3,000'	$101,000
46	Channel	6'	4,600'	1:1	3'	Channel	8' width 3' depth 2:1 side slopes Streambank protection	$172,000
36	Channel	6'		2:1	4'	Channel	2' Streambank protection Lower 3,000'	$66,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $2,854,000

Round To: $2,900,000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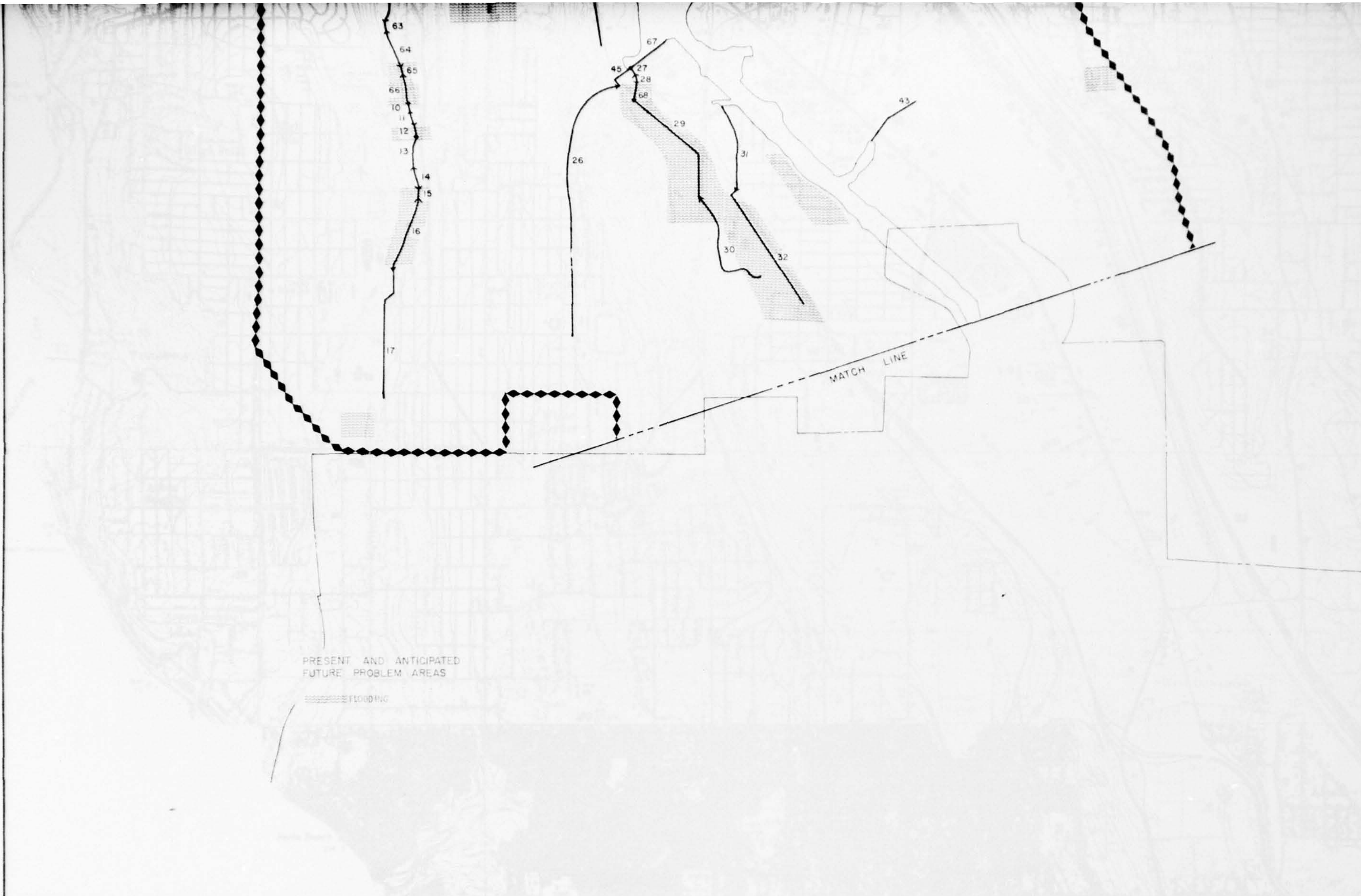

LEGEND

SUB-BASIN BOUNDARY
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NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

DUWAMISH ESTUARY

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 10 OF 2

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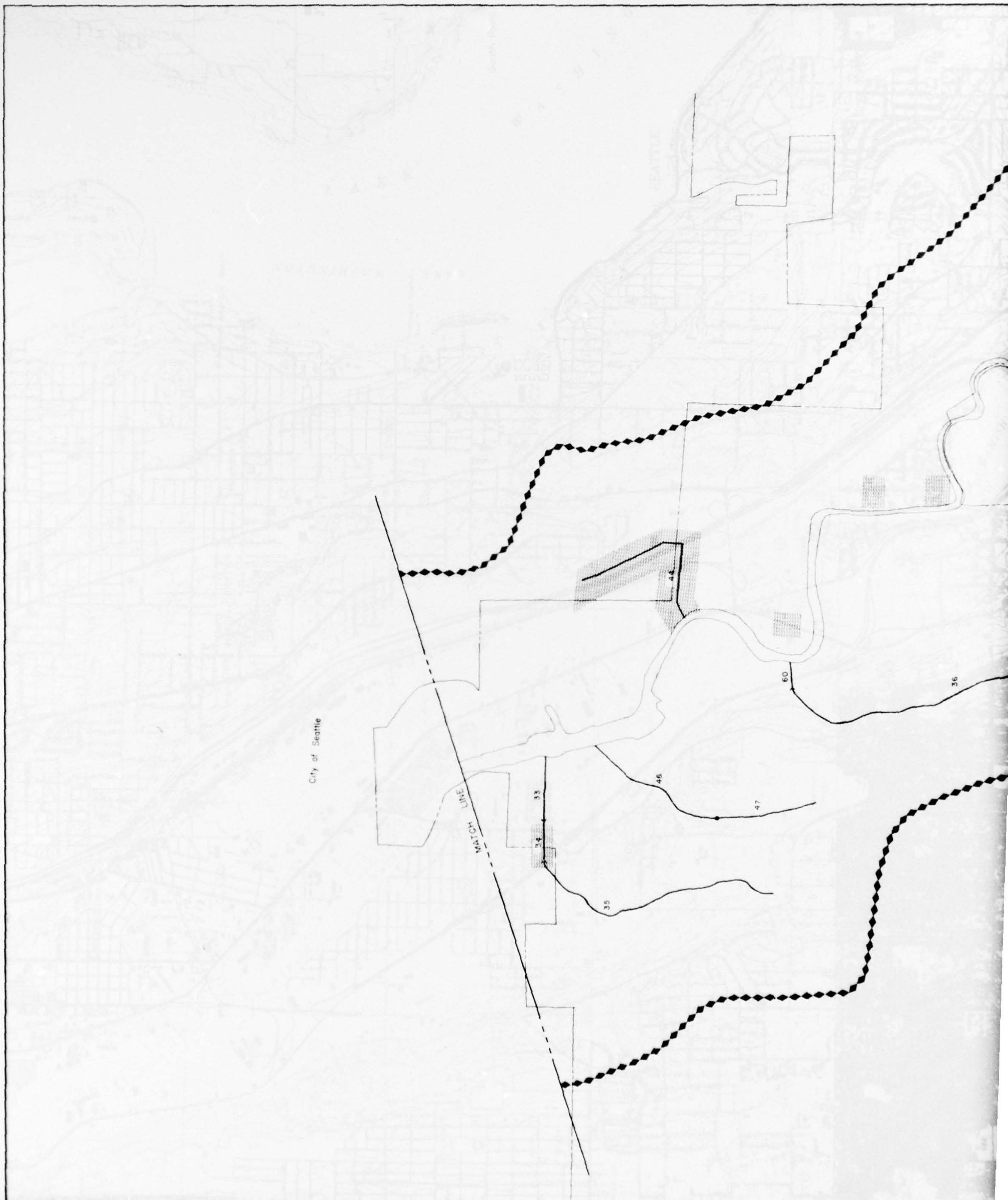
City of Seattle
MATCH LINE
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LEGEND

- SUB-BASIN BOUNDARY
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- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
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- COUNTY (METRO) BOUNDARY
- LEVEE
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- HOLDING POND OR LAKE

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FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

DUWAMISH ESTUARY

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2 OF 2

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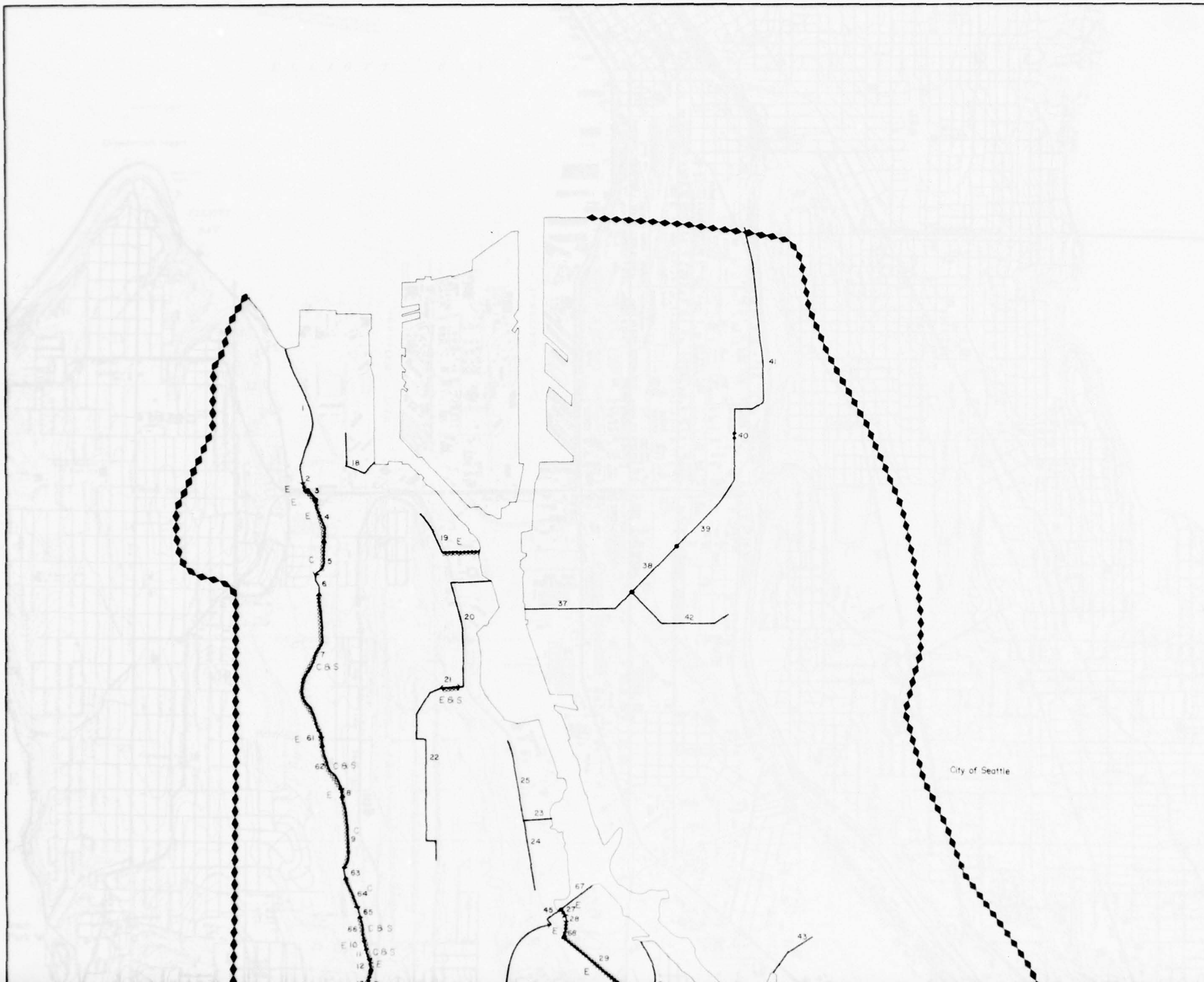
City of Seattle

LEGEND

SUB-BASIN BOUNDARY
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MANHOLE, INLET, OR JUNCTION
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CITY LIMITS
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FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

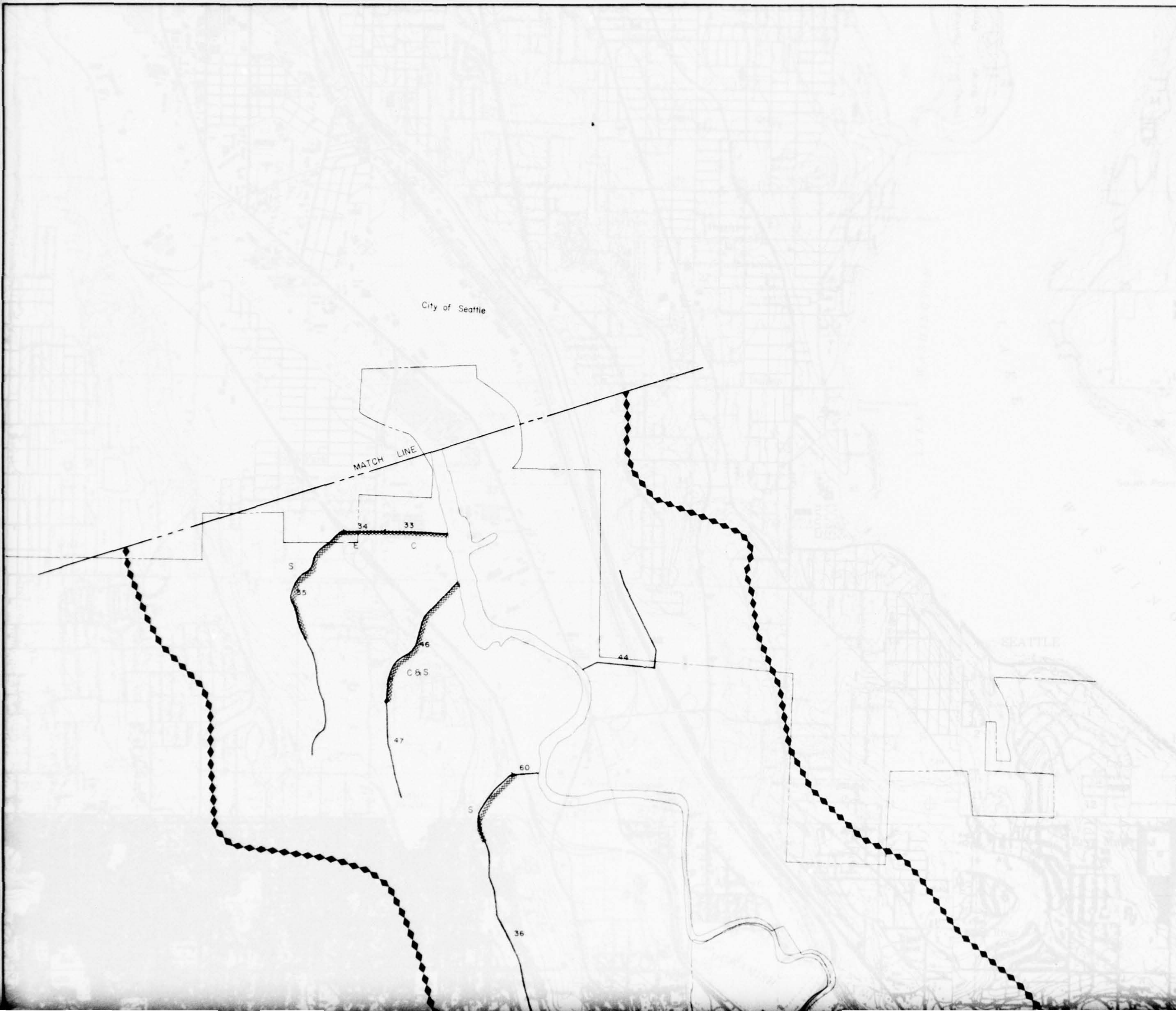
DUWAMISH ESTUARY

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1b OF 2



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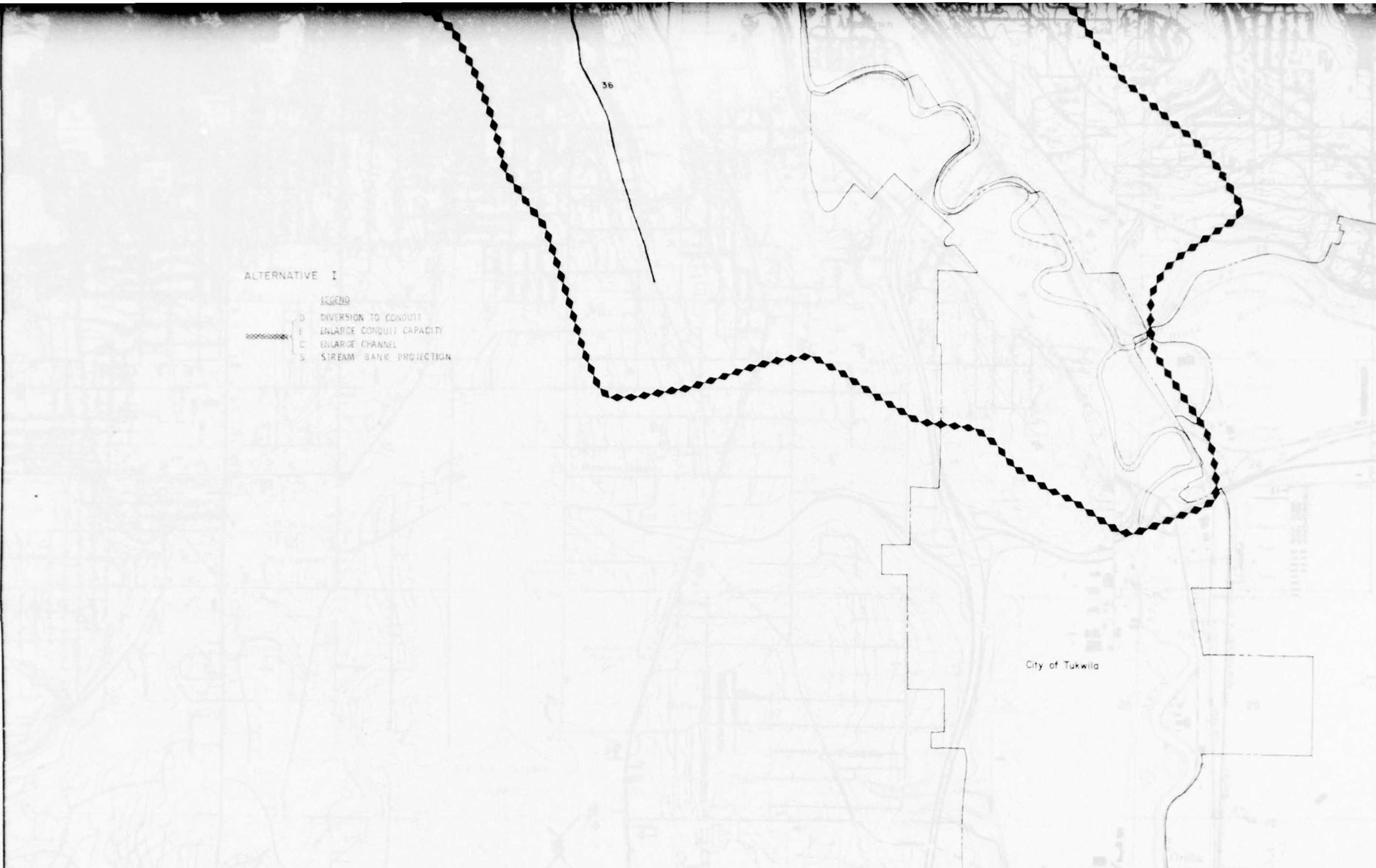

LEGEND

SUB-BASIN BOUNDARY
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EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
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CULVERT
HOLDING POND OR LAKE

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FEET 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

DUWAMISH ESTUARY

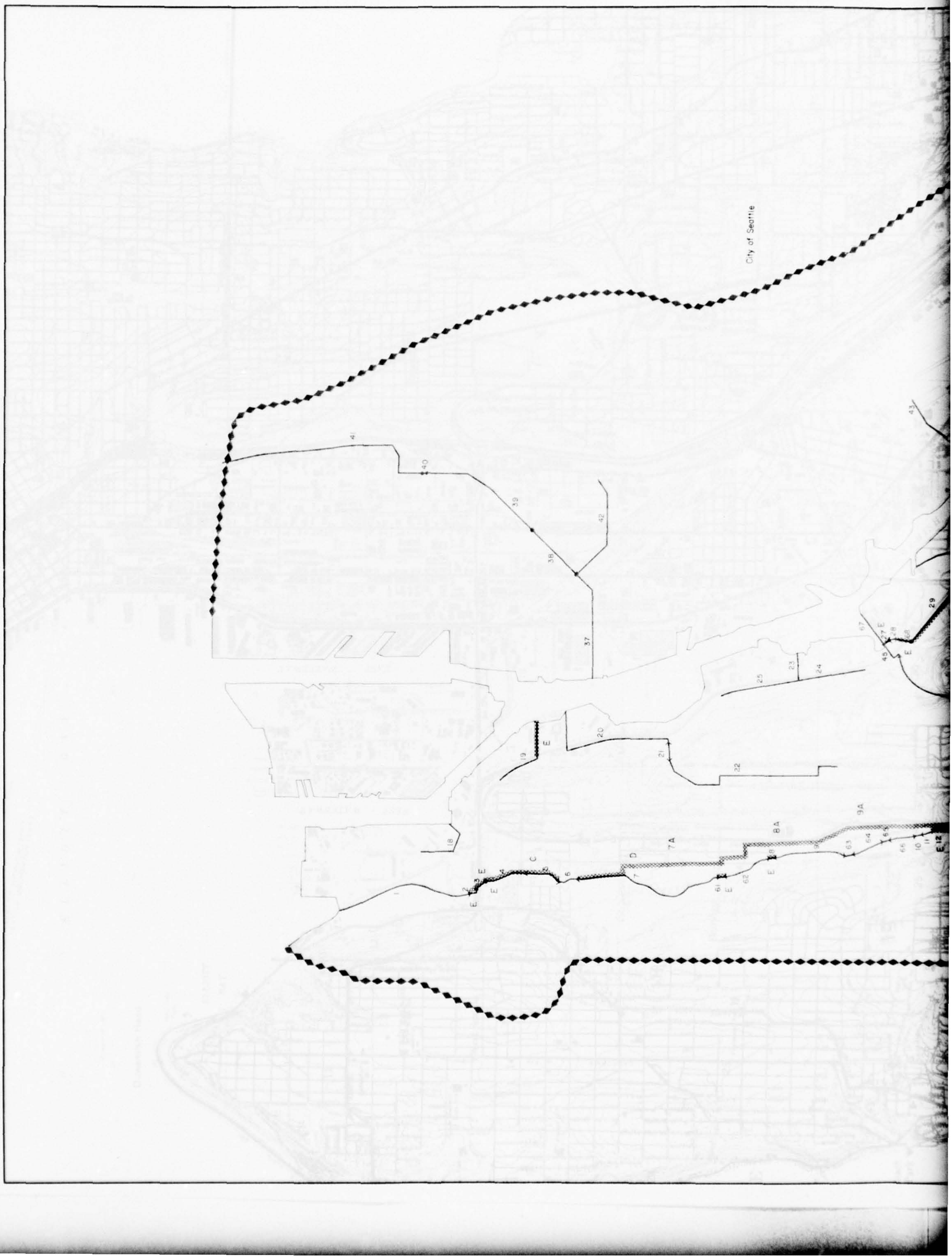
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2b OF 2

2


City of Seattle
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LEGEND

SUB-BASIN BOUNDARY
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MANHOLE, INLET, OR JUNCTION
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HOLDING POND OR LAKE

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FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

DUWAMISH ESTUARY

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1.5 OF 2

City of Seattle
MATCH LINE
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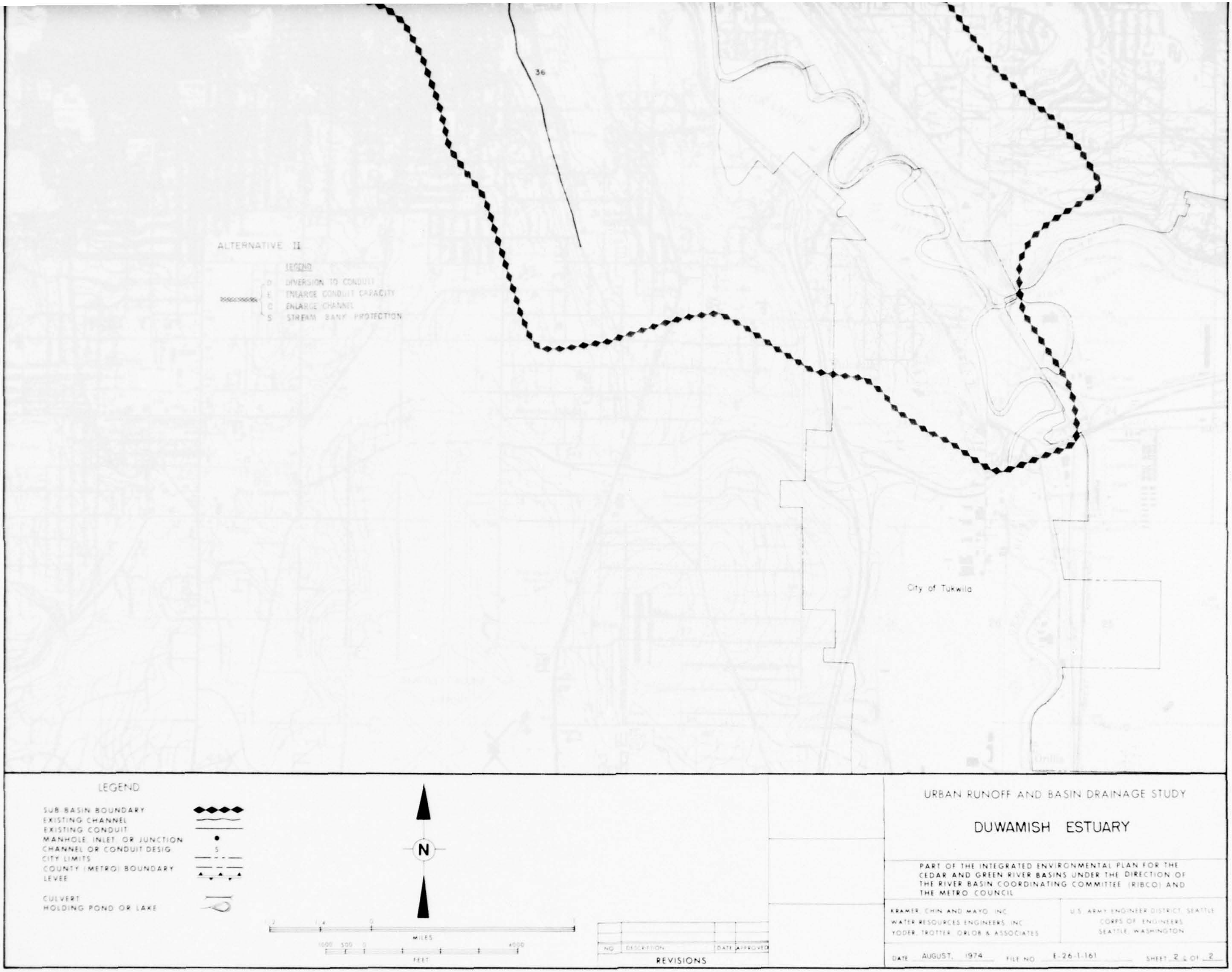

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

DUWAMISH ESTUARY

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2 of 2

2

REGIONAL SUB-BASIN P-1

UPPER PUGET SOUND

GENERAL DESCRIPTION

The Upper Puget Sound Sub-Basin is the northern-most drainage sub-basin of the Study Area adjacent to Puget Sound. The sub-basin is bordered by Puget Sound, Mukilteo, Paine Field, Highway 99, and the King County-Snohomish County line.

The sub-basin is characterized by a plateau area on the east that descends steeply to Puget Sound. Steep ravines form the natural drainage system that collects runoff from the plateau area and the hillsides. A few of the streams cross small tidal plains, but in most cases the streams enter the Sound across the beaches. Each stream crosses under the Burlington Northern railroad track that is parallel to Puget Sound at the water's edge.

Typical streams in the sub-basin and some of their characteristics are:

Stream	Category	Drainage Area	Discharge
Big Gulch	III	2.0 sq. mi.	Chenault Beach
Lake Serene system	III	2.6 sq. mi.	Picnic Point
Lunds Gulch	III	2.2 sq. mi.	Meadowdale Golf Course
Shell Creek	III	1.7 sq. mi.	North Edmonds
Shelleberger Creek	III	2.2 sq. mi.	South Edmonds
Deer Creek	III	0.5 sq. mi.	Woodway Estates

There is sparse residential development in the area from Mukilteo south to Lunds Gulch. Most of the area between Big Gulch and Lake Serene drainage streams is undeveloped and it offers numerous residential sites. Two public beaches are in this area, but most of the shoreline offers little beach area and consists of mud flats or a narrow rocky strip of land.

From Lunds Gulch south, the area is extensively developed with single-family homes. The Edmonds area contains numerous multiple-family dwellings, some commercial enterprise and industry. There are several recently-constructed school buildings. Woodway (Deer Creek basin) consists of large multi-acre private estates.

Land-use categories and percentages of area have been determined for existing and potential future conditions as indicated by the following table.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	P.S.G.C. Land Use Projection Corridor
Single Family	35	68	55
Multiple Family		2	5
Commercial/Services	< 1	5	5
Govt. and Educ.	1	5	5
Industrial	< 1	5	5
Parks/Dedicated Open Space	5	10	10
Agriculture			
Airports, Railyards, Freeways, Highways	5	5	5
Unused Land	53		10
Water			
Total	100	100	100
Total Impervious Area	15	40	35

Snohomish County has jurisdiction for approximately 60 percent of the sub-basin, including Paine Field. The cities of Mukilteo, Lynnwood, Edmonds and Woodway have separate jurisdictions over the remainder.

Industry presently uses many of the larger, former Air Force hangars located between the runways in the center of Paine Field as well as the eastern and southern perimeters of the field. A number of community services and some college classes also are located in the south complex of former Air Force buildings.

Mainly commercial enterprise is located on Highway 99 and it extends back from the highway in certain locations. However, people living in choice water areas such as Lake Serene, are not likely to tolerate infringement by business. Industrial growth is expected in the Edmonds lowlands around Shelleberger Creek.

NATURE OF EXISTING DRAINAGE SYSTEM

With few exceptions, the several small streams originate in the upland plateaus then drop steeply through ravines to the Sound. The upland regime is characterized by mild slopes with sandy and gravelly channel beds. Storm drainage from the portion of Paine Field within the sub-basin discharges into Big Gulch Creek. The typical drainage practice of residential developments througout the sub-basin is to discharge storm runoff directly to adjacent streams which often causes serious erosion problems. The City of Edmonds has constructed trunk lines for storm drainage through the Central Business District and for the larger residential area bordering Woodway. The City has made an effort to preserve natural streams, such as Shell Creek and Deer Creek, for environmental enhancement of the community. Shelleberger Creek has been extensively landscaped by individual property owners and is used for irrigating lawns and gardens. Small detention ponds have been constructed on smaller streams by individual land owners. The lower reaches of most streams are fed by springs and they flow perennially.

DRAINAGE PROBLEMS

Major problem areas are in the urbanized sectors of Edmonds and Lynnwood. Ponding is a common occurrence because storm drains and culverts do not have adequate capacity to discharge the runoff resulting from increased development. Substantial erosion is occurring in natural streams and will become worse as runoff is increased. Steep bluffs along Puget Sound, and several ravines within the sub-basin, have high slippage potential, and several cases of sliding have been noted. This problem is a consequence of soil and geologic conditions, but is compounded by the saturation of soils along the bluff and by any construction that undercuts the slopes or denudes the soil.

Simulation of storm drainage with future land-use projections indicates that major storm drains and culverts will be surcharged. This is reasonable since the City of Edmonds sizes their facilities for accommodating runoff for a five-year storm, whereas this analysis is based upon a 10-year storm. Many culverts have inadequate capacity for even existing land-use conditions. Significantly, the system along Edmonds Way will need to be enlarged even more than is specified by the Edmonds Comprehensive Plan. The Shell Creek and Olympic Boulevard systems also will be surcharged. Anticipated problems in natural systems located north of Edmonds and Mukilteo will be primarily erosion and sliding.

Both the 2000 Comprehensive and Corridor Land-Use Plans indicate a general urbanization of the upper Puget Sound area. The existing drainage problems will become more severe because of increases in impervious areas and faster runoff. More extensive flooding will occur in the upper reaches. Greatly increased erosion and sedimentation will occur in the lower reaches. The total impervious area in this sub-basin under the 2000 Comprehensive Land-Use Plan will increase from the

existing 15% level to a 45% level and under the 2000 Corridor Land-Use Plan to a 35% level, as shown by the table of projected land uses.

The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Plans. Therefore, the drainage alternatives presented herein are applicable to both plans.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

No regional plan has been formulated for this sub-basin. The Snohomish County WASH-USE-1 study did not provide a plan for this area. The City of Edmonds developed a Comprehensive storm-drainage plan in 1965 and this plan is being implemented as development takes place. Lynnwood also has a Comprehsive Drainage Plan for the city which addresses part of the sub-basin's drainage needs.

Planning preferences for this area were inferred from planning documents obtained from the cities of Edmonds and Lynnwood and Snohomish County. Ponds such as Five Corners Lake, Lake Serene and several other upland ponds are being used for recreation and wildlife habitat. Natural streams, such as Shell Creek and Shelleberger, are neighborhood amenities and in some cases these have been landscaped to enhance adjacent properties. Lunds Gulch and Big Gulch are natural areas that are very sensitive to change. Alternatives were developed with provisions to preserve these natural elements and to alleviate other anticipated flooding and erosion problems.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Upper Puget Sound Sub-Basin as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in development of alternative plans for drainage control as described below.

Two major alternative plans were studied for solving the Upper Puget Sound drainage problems; the first employs holding ponds, diversions, streambank protection and some flood-plain zoning, and the second employs the same structural elements together with land-use controls. Description of these two alternatives follows.

ALTERNATIVE PLAN I

General Concept

Alternative Plan I uses traditional solutions to storm drainage problems. Emphasis is placed upon disposal of runoff in the most direct manner, with some holding pond detention. Both costs and environmental considerations were secondary to drainage efficiency.

Major Features

Drainage from this sub-basin includes ten major and several minor stream systems. Improvements were many and varied because the existing drainage systems would be inadequate for future land use conditions. Large or parallel drains are specified. Diversion drains are provided as an alternative to streambank protection where existing right-of-ways or drainage area considerations permitted. Existing ponds also were utilized, although to a lesser extent than in Alternative Plan II. Several additional drainage systems were provided in those areas that are presently undeveloped where substantial single-family housing and industrial development is indicated by the future land-use plan.

Additional storm drainage system enlargements to those currently being made will be required for the Edmonds Way trunk system. Also the Olympic Boulevard system essentially will require all new pipe, and the Perrinville Canyon Stream is provided with streambank protection. Diversion drains are specified for placement along both ridges of the Shelleberger Creek to preserve the natural stream.

From Lunds Gulch northward, extensive new drainage system improvements will be required since most of this area will go from undeveloped vacant land to suburban residential and industrial land use. Advantage is taken of a pond site at the head of Lunds Gulch to divert runoff from areas east of 52nd Avenue into a holding basin. Another diversion extends from 52nd Avenue westward along Norma Beach Road directly to Puget Sound. These diversions would preserve the natural features in the lower reaches of Lunds Gulch and in the stream that proceeds eastwardly from Norma Beach.

Similarly, a trunk drain from Lake Serene along Picnic Point Road to the Sound would intercept the major portion of runoff to that ravine and would allow full development of the uplands in a corridor along Beverly Park Road. A pipe could be constructed in the lower reach of the ravine along an existing road. In the next ravine north of Picnic Point, extensive channel protection would be required. A major trunk drainage canal would be constructed to Chenault Beach Road from the head of this ravine to intercept upland runoff which would otherwise be discharged into the Picnic Point Road ravine.

The uplands of the head of Big Gulch are already substantially industrialized with Paine Field facilities and further industrial expansion is expected there. Therefore, improvements to the lower reach of Big Gulch are required for streambank protection. An interceptor trunk drain would take runoff from the more developed areas and would discharge directly to the lined channel. The holding pond at Paine Field would reduce flows to the upper stream end of Big Gulch.

The uplands north of Big Gulch to Mukilteo would be provided with two trunk drainage systems. The first would intercept runoff from south

of Nelson's Corner and discharge directly to the Sound. The second would follow Mukilteo Boulevard up to Nelson's Corner and provide drainage to most of that corridor. The several smaller very unstable ravines south of Mukilteo would thereby be given much more protection from infiltration and storm runoff.

Cost

The total cost of drainage improvements is estimated to be $6,500,000 in Alternative Plan I.

ALTERNATIVE PLAN II

General Concept

On-site runoff control is assumed throughout the sub-basin as a primary consideration for this alternative. This condition applies at peak runoff rates under future land use and would be limited to 25% of that under existing conditions. Also, some diversions and holding ponds are specified so as to preserve most of the existing natural streams. Future development control should be exercised with respect to the instability of soils along the steep bluffs and ravines and the need to divert storm drainage away from these areas.

Major Features

Opportunities for runoff control and holding ponds are limited in the suburban areas of Edmonds and Lynnwood, therefore, system enlargement and diversions are similar to those discussed in Alternative Plan I. At present, the area from Lunds Gulch northward to Paine Field are relatively undeveloped and improvements to these drainage systems could be lesser in magnitude. The major expense for this system would be for improvements to the systems in Edmonds and Lynnwood. A holding pond is included in the system along Olympic Boulevard to reduce peak-flow rates to the Perrinville Canyon system.

A diversion along 52nd Avenue is specified as per Alternative Plan I. A detention pond at a site upstream from the existing box culvert at the head of Lunds Gulch reduces the requirements for downstream improvements. Diversions along 148th also would make disruptions to the stream at Norma Beach unnecessary.

The Picnic Point stream system flowing to Lake Serene would require only a few improvements if a runoff-control policy were implemented. A diversion along the lower reach that would discharge the combined flow from the confluence of the two streams, proceeding upland from the Picnic Point area, would be desirable.

The Big Gulch and Mukilteo systems require enlargement to accommodate drainage from existing development. Drainage from that portion

of Paine Field, which lies within the Upper Puget Sound Sub-Basin, discharges through an existing culvert. If this existing culvert is used to create a pond with 27 acre feet of storage, only the lower reach of Big Gulch needs to be lined to stabilize the channel above the railroad crossing. Other lesser ravines and streams would be protected from increased runoff by provision of a diversion drain along Mukilteo Boulevard. The holding pond near Nelson's Corner would further decrease peak flows into that ravine.

Cost

The total estimated capital cost for this alternative is $4,000,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and with alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities*	Alternative Plan I	Alternative Plan II
Pressure drain outfall, Edmonds	180	360	340
Pond outfall in Edmonds with control	130	130	130
Pond outfall without control	240	290	270
Shell Creek outfall	60	230	210
Outfall at Ocean Ave.	30	90	80
Perrinville Canyon outfall	40	440	170
Lunds Gulch with diversion at 52nd Avenue	-	190	130
Lunds Gulch without diversion at 52nd Avenue	380	390	270
Outfall at Norma Beach	170	170	110

Location	Existing Facilities*	Alternative Plan I	Alternative Plan II
Outfall at Picnic Point	220	590	60
Big Gulch with control at Paine Field	-	320	40
Big Gulch without control at Paine Field	330	620	310
Outfall at Mukilteo without diversion on Mukilteo Blvd.	30	60	60

* Peak discharges for existing systems may be limited because of upstream control facilities.

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternative plans for this sub-basin. This procedure was followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements.

The various structural solutions were checked against the appropriate criteria. The various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs enlargement of conduits, channelization, diversions and holding ponds, was a minus 22 out of a possible range from a positive total of 108 and a negative total of 108. The total evaluation rating for Alternative Plan II, which employs all the same elements as Alternative Plan I, together with runoff control, was a minus 2.

Both alternative plans were judged to be effective in controlling drainage. Both plans involved certain sacrifices of human values and human uses of the land once the system is built. Environmentally, Alternative Plan II clearly offered more resource preservation potential than Alternative Plan I which requires considerable more construction than Alternative Plan II.

Both alternatives include parts of present planning efforts by the cities of Edmonds and Lynnwood. Extensive cooperative effort would be required with Snohomish County before either plan can be fully realized. Both of the plans involve commitments for the use and management of natural resources because they rely upon certain structural

treatments for all or part of their solutions. Therefore, neither alternative can be said to be clearly superior to the other in this regard. Alternative Plan II requires considerably less construction, particularly in the northern undeveloped areas of the sub-basin, thus considerably decreasing the environmental damage done to this area.

Alternative Plan II relies upon runoff control for future land development. This treatment, if it is to be part of the chosen alternative, should be implemented as an early organized effort. Any portion of the sub-basin that develops without these combined controls will require more structural treatment than Alternative Plan II can accommodate. This issue should be brought to the attention of all citizens and their local agencies.

CONCLUSIONS

Alternative Plan II is clearly superior to Alternative Plan I because of the relatively undeveloped nature of much of this sub-basin, but it does require immediate action to protect and preserve the natural values. This action would require runoff control at or near existing rates for any new development.

Because of runoff control provided by Alternative Plan II, flow rates are drastically reduced from those set forth in Alternative Plan I for those streams in the northern section of this sub-basin. There are many opportunities to implement runoff-control policy. Peak flow rates could be substantially reduced from existing conditions in presently developed urban areas of Edmonds, Lynnwood and Mukilteo by the use of detention ponds in the drainage systems as they are improved. The lower cost, together with environmental amenities, make Alternative Plan II a desirable solution to storm drainage problems in the Upper Puget Sound Sub-Basin. Snohomish County, Edmonds, Lynnwood and Mukilteo should establish an effective agreement on a master drainage plan incorporating the conditions of Alternative Plan II. All agencies should then move to implement and enforce the required runoff controls within their own jurisdiction.

RUNOFF QUALITY SUMMARY
UPPER PUGET SOUND

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
	2000 Corridor ** Land Use						
Edmonds	I	360	11	6.1×10^4	.3	1.3	.1
	II	340	20	1.0×10^5	.5	1.3	.1
Shell Creek	I	230	12	4.5×10^5	.4	.9	.1
	II	210	13	5.0×10^5	.5	1.0	.1
Lunds Gulch	I	390	6	1.1×10^5	.1	.4	.05
	II	270	7	1.3×10^5	.1	.5	.05
Picnic Point	I	590	4	7.1×10^4	.05	.3	.05
	II	60	7	1.4×10^5	.1	.5	.05
Big Gulch	I	320	6	4.5×10^4	.2	.7	.05
	II	40	12	6.6×10^4	.5	1.6	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.
** 2000 Comprehensive land use was not modeled.

EVALUATION MATRIX

UPPER PUGET SOUND

ALTERNATIVES	SUB TOTAL	EFFECTIVENESS: Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	SUB TOTAL	HUMAN VALUES: Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	SUB TOTAL	ENVIRONMENTAL FACTORS: High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	SUB TOTAL	IMPLEMENTATION: Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	SUB TOTAL	RESOURCE REQUIREMENTS: Energy	Materials	Land	Capital	RATING TOTAL
		CRITERIA WEIGHT									CRITERIA WEIGHT								CRITERIA WEIGHT										CRITERIA WEIGHT							CRITERIA WEIGHT				
		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	+8									+2								-10										-16							-6					-22
II	+10									+3								+4										-16							-3					-2

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Upper Puget Sound

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
4	Pipe	36"	2,000'			Parallel Pipe	60"	$240,000
2	Pipe	36"	1,300'			Parallel Pipe	24"	$55,000
3	Pipe	42"	3,300'			Parallel Pipe	42"	$261,000
6	Pipe	One 36" One 42"	2,300'			Parallel Pipe	42"	$182,000
7	Pipe	54"	700'			Parallel Pipe	42"	$55,000
9	Pipe	54"	900'			Parallel Pipe	42"	$71,000
16	Culvert	24"	100'			Parallel Pipe	36" Includes inlet and outlet	$12,000
17	Channel	6'	400'	2:1	4'	Channel	2' depth Streambank protection	$6,000
18	Culvert	3'	200'	0	3'	Parallel Pipe	36" Includes inlet and outlet	$19,000
19	Channel	6'	600'	2:1	4'	Channel	2' depth Streambank protection	$9,000
20	Pipe	30"	100'			Parallel Pipe	48"	$17,000
22	Pipe	36"	900'			Parallel Pipe	36"	$59,000
24	Lake	Existing area 1 acre				Holding Pond	15 AF 8 acres	$40,000
33	Pipe	24"	100'			Parallel Pipe	30"	$10,000
34	Channel	8'	1,000'	2:1	6'	Channel	2' depth Streambank protection	$15,000
36	Channel	8'	1,400'	2:1	6'	Channel	3' depth Streambank protection	$29,000
331	None					Diversion Pipe	27" 4,500'	$212,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Upper Puget Sound

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
332	None					Diversion Pipe	27" 3,200'	$150,000
351	None					Diversion Pipe	24" 3,000'	$126,000
352	None					Diversion Pipe	21" 2,500'	$90,000
37	Pipe	30"	700'			Diversion Pipe	27" 1,800'	$85,000
451	None					Diversion Pipe	36" 2,800'	$185,000
46	Pipe	24"	100'			Parallel Pipe	24" Includes inlet and outlet	$8,000
48	Pipe	18"	100'			Parallel Pipe	36"	$11,000
50	Channel	6'	500'	2:1	4'	Channel	2' depth Streambank protection	$7,000
49	Pipe	24"	700'			Parallel Pipe	24"	$29,000
51	Pipe	36"	100'			Parallel Pipe	48"	$17,000
52	Channel	6'	400'		4'	Channel	2' depth Streambank protection	$6,000
53	Pipe	30"	2,600'			Parallel Pipe	21"	$94,000
54	Pipe	36"	1,800'			Parallel Pipe	21"	$65,000
55	Pipe	48"	600'			Parallel Pipe	42"	$47,000
99	Pipe	18"				Parallel Pipe	42" 4,800'	$379,000
98	Pipe	18"				Parallel Pipe	48" 4,400'	$409,000
56	Channel	8'	4,200'	2:1	4'	Channel	3' depth Streambank protection	$82,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Upper Puget Sound

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
57	Pipe	30"	100'			Parallel Pipe	78" Includes inlet and outlet	$29,000
58	Channel	8'	300'	2:1	4'	Channel	3' depth Streambank protection	$6,000
61	Pipe	24"	100'			Parallel Pipe	24" includes inlet and outlet	$8,000
67	Channel	6'	1,000'	2:1	4'	Channel	2' depth Streambank protection	$10,000
723	None					Diversion Pipe	27" 2,800'	$132,000
722	None					Diversion Pipe	30" 2,500'	$135,000
721	None					Diversion Pipe	30" 4,500'	$243,000
743	None					Diversion Pipe	30" 3,500'	$189,000
742	None					Diversion Pipe	30" 3,500'	$189,000
741	None					Diversion Pipe	36" 4,500'	$297,000
77	Pipe	36"	200'			Parallel Pipe	54" Includes inlet	$26,000
78	Channel	9'	2,600'	2:1	6'	Diversion Pipe	54"	$276,000
79	Pipe	54"	100'			Diversion Pipe	60'	$12,000
80	Channel	9'	700'	2:1	4'	Diversion Pipe	60"	$67,000
82	Channel					Channel	6' width 4' depth 3,000'	$45,000
83	Channel	6'	3,700'	2:1	4'	Channel	3' depth 1,700' Streambank protection	$128,000
861	None					Diversion Pipe	48" 2,700'	$251,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Upper Puget Sound

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
86	Channel	4'	2,800'	2:1	4'	Channel	4' depth Streambank protection	$79,000
89	Pipe	24"				Holding Pond	16 AF 4 acres	$23,000
91	Channel	6'	2,800'	2:1	4'	Channel	3' depth 2:1 side slopes Streambank protection	$57,000
912	None					Diversion Pipe	36" 2,500'	$165,000
911	None					Diversion Pipe	27" 5,500'	$259,000
961	None					Diversion Pipe	30" 5,000'	$270,000
97	Channel	4'	2,400'	2:1	4'	Diversion Pipe	27" 3,200'	$150,000
691	None					Diversion Pipe	36" 5,000'	$330,000
69	Box Culvert	4'			4'	Holding Pond and Box Inlet	14 AF 3.5 acres	$24,000
71	Channel	6'	5,800'	2:1	4'	Channel	3' depth 3,000' Streambank protection	$61,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $6,543,000

Round To: $6,500,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Upper Puget Sound

ELEMENT NUMBER	EXISTING FACILITIES: TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES: TYPE		ESTIMATED CAPITAL COST
4	Pipe	36"	2,000'			Parallel Pipe	60"	$240,000
2	Pipe	36"	1,300'			Parallel Pipe	24"	$55,000
3	Pipe	42"	3,300'			Parallel Pipe	42"	$261,000
6	Pipe	One 36" One 42"	2,300'			Parallel	42"	$182,000
7	Pipe	54"	700'			Parallel Pipe	42"	$56,000
9	Pipe	54"	900'			Parallel Pipe	42"	$71,000
16	Culvert	24"	100'			Parallel Pipe	36" includes inlet and outlet	$12,000
17	Channel	6'	400'	2:1	4'	Channel	2' depth Streambank protection	6,000
18	Culvert	3'	200'	0	3'	Parallel Pipe	36" includes inlet and outlet	$19,000
19	Channel	6'	600'	2:1	4'	Channel	2' depth Streambank protection	$9,000
20	Pipe	30"	100'			Parallel Pipe	48"	$17,000
22	Pipe	36"	900'			Parallel Pipe	36"	$59,000
24	Lake	Existing area 1 acre				Holding Pond	15 AF 8 acres	$40,000
34	Channel	8'	1,000'	2:1	6'	Channel	2' depth Streambank protection	$15,000
36	Channel	8'	1,400'	2:1	6'	Channel	3' depth Streambank protection	$29,000
331	None					Diversion Pipe	27" 4,500'	$212,000
332	None					Diversion Pipe	27" 3,200'	$150,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Upper Puget Sound

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
351	None					Diversion Pipe	24" 3,000'	$126,000
352	None					Diversion Pipe	21" 2,500'	$90,000
37	Pipe	30"	700'			Diversion Pipe	24" 1,800'	$76,000
451	None					Diversion Pipe	27" 2,800'	$132,000
48	Pipe	18"	100'			Parallel Pipe	21" includes inlet and outlet	$7,000
49	Pipe	24"	700'			Parallel Pipe	24"	$29,000
50	Channel	6'	500'	2:1	4'	Channel	2' depth Streambank protection	$7,000
51	Pipe	36"	100'			Parallel Pipe	48"	$17,000
52	Channel	6'	400'		4'	Channel	2' depth Streambank protection	$6,000
53	Pipe	30"	2,600'			Parallel Pipe	21"	$94,000
99	Pipe	18"				Parallel Pipe	36" 4,800'	$317,000
98	Pipe	18"				Parallel Pipe	42" 1,500'	$119,000
302	None					Holding Pond and Outlet	10.6 AF 2 acres	$16,000
300	Pipe	18"				Parallel Pipe	24" 2,000'	$84,000
56	Channel	8'	4,200'	2:1	4'	Channel	2' depth Streambank protection	$61,000
57	Pipe	30"	100'			Parallel Pipe	54" includes inlet and outlet	$19,000
58	Channel	8'	300'	2:1	4'	Channel	3' depth Streambank protection	$6,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Upper Puget Sound

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
61	Pipe	24"	100'			Parallel Pipe	18" includes inlet and outlet	$6,000
67	Channel	6'	1,000'	2:1	4'	Channel	2' depth Streambank protection	$10,000
691	None					Diversion Pipe	21" 5,000'	$180,000
69	Culvert	4'		0	4'	Holding Pond and Box Inlet	10 AF 2.5 acres	$18,000
71	Channel	6'	5,800'	2:1	4'	Channel	2' depth 3,000' Streambank protection	$44,000
723	None					Diversion Pipe	21" 2,800'	$101,000
722	None					Diversion Pipe	24" 2,500'	$105,000
721	None					Diversion Pipe	24" 4,500'	$189,000
77, 78 79, 80		Refer to Alternative I				Diversion Pipe	36" 3,600'	$238,000
73	Lake					Outlet Structure	24" 20'	$4,000
83	Channel	6'	3,700'	2:1	4'	Channel	2' depth 1,500' Streambank protection	$22,000
89	Pipe	24"				Holding Pond	27 AF 5.5 acres	$32,000
91	Channel	6'	2,800'	2:1	4'	Channel	2' depth Streambank protection	$41,000
93	Pipe	24"				Holding Pond	.8 AF .25 acre	$1,000
961	None					Diversion Pipe	27" 5,000'	$235,000
97	Channel	4'		2:1	4'	Diversion Pipe	24" 3,200'	$134,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $3,999,000
Round To: $4,000,000


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City of Everett
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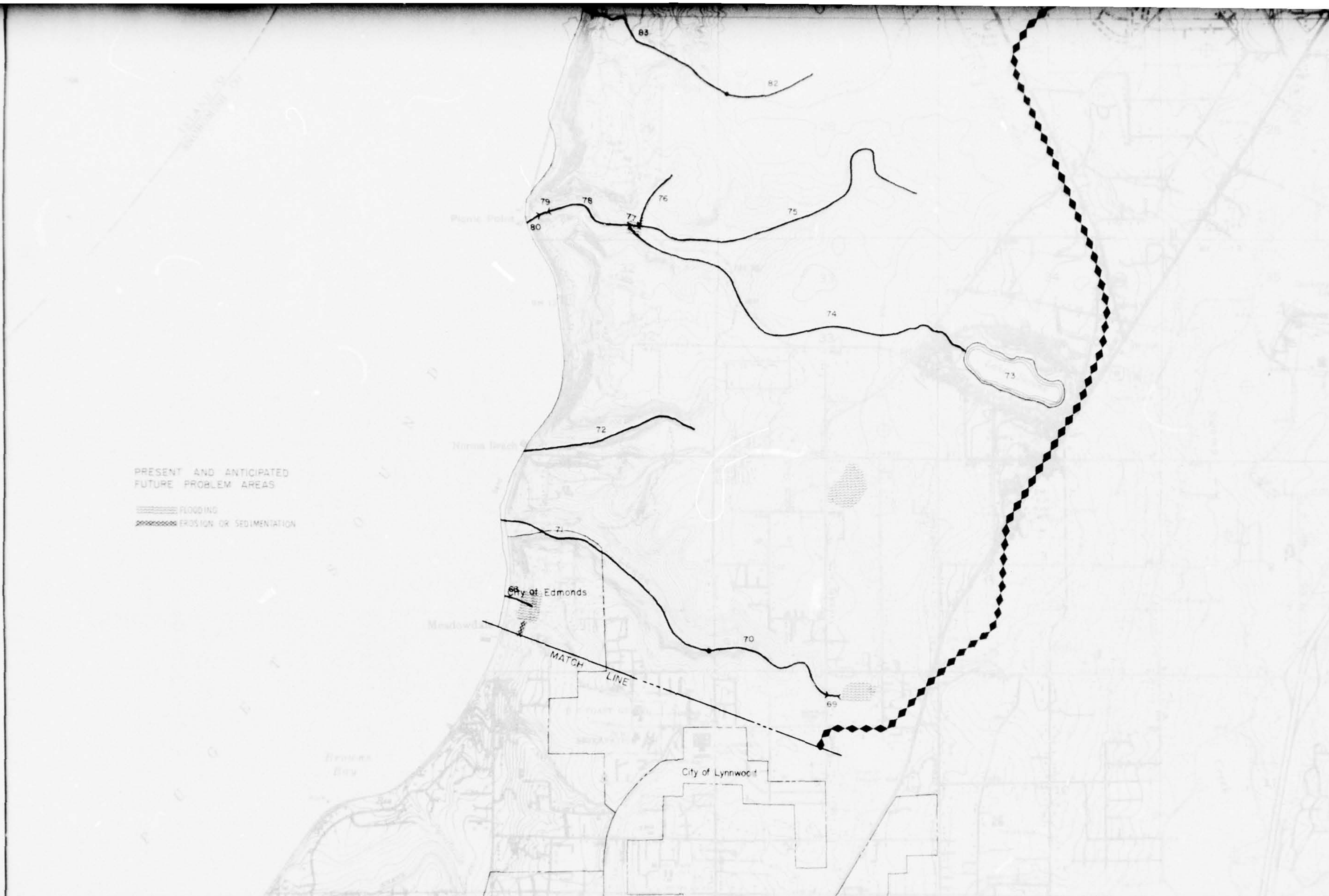

LEGEND

SUB BASIN BOUNDARY
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HOLDING POND OR LAKE

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FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

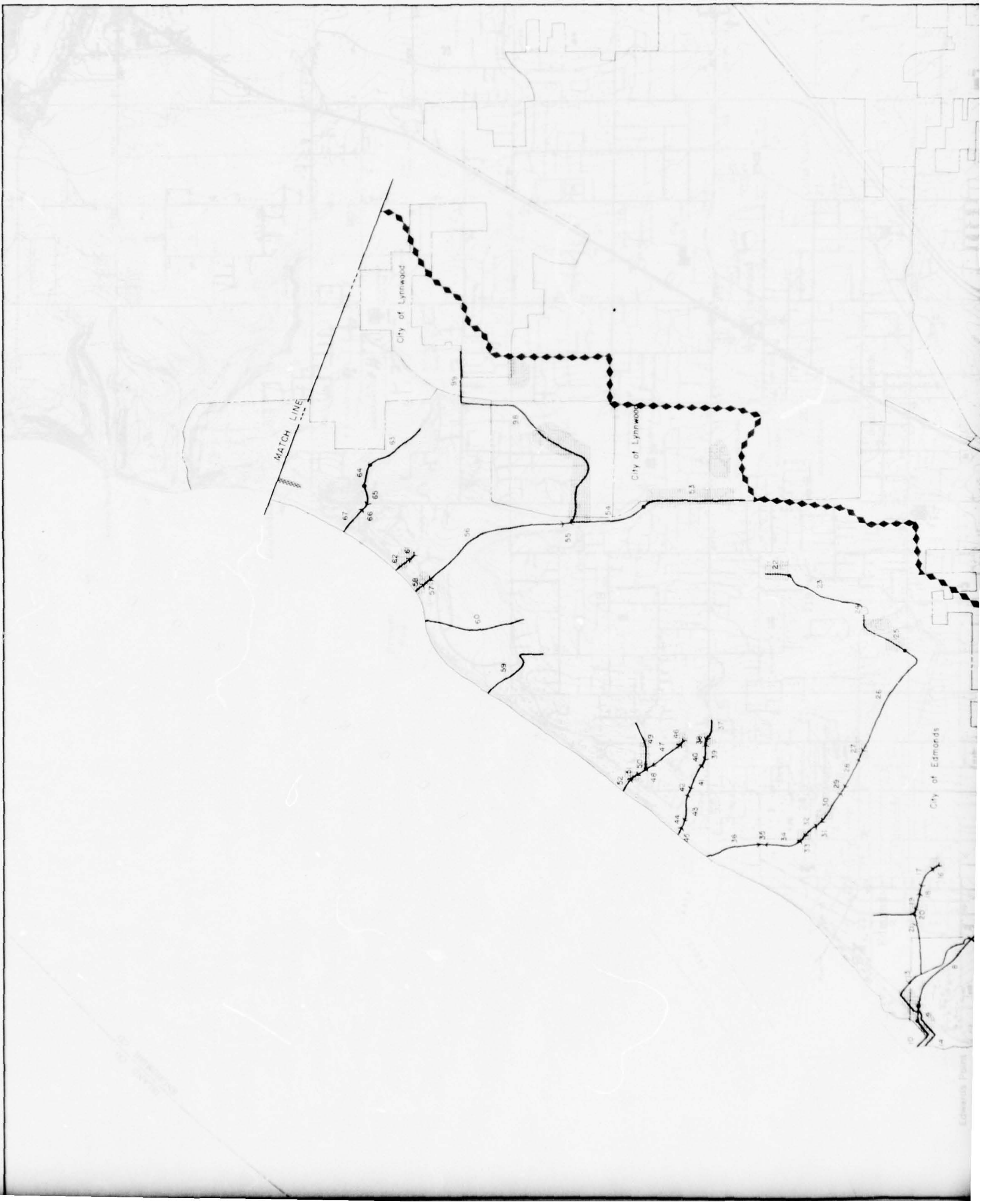
UPPER PUGET SOUND

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

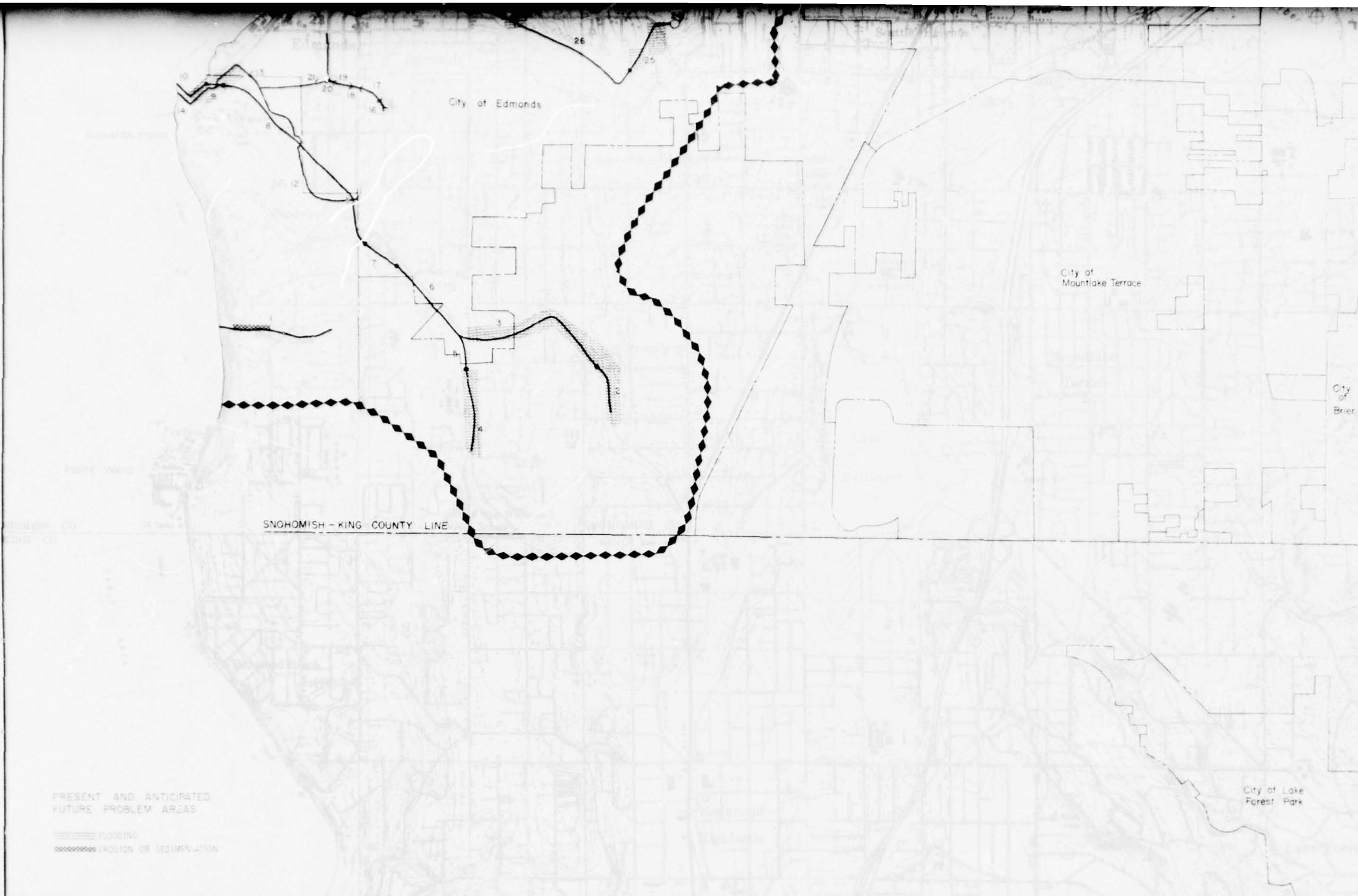
KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1 OF 2



MATCH LINE
City of Lynnwood
City of Lynnwood
City of Edmonds



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CHANNEL OR CONDUIT DESIG.
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

MILES

FEET

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U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2B OF 2

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NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

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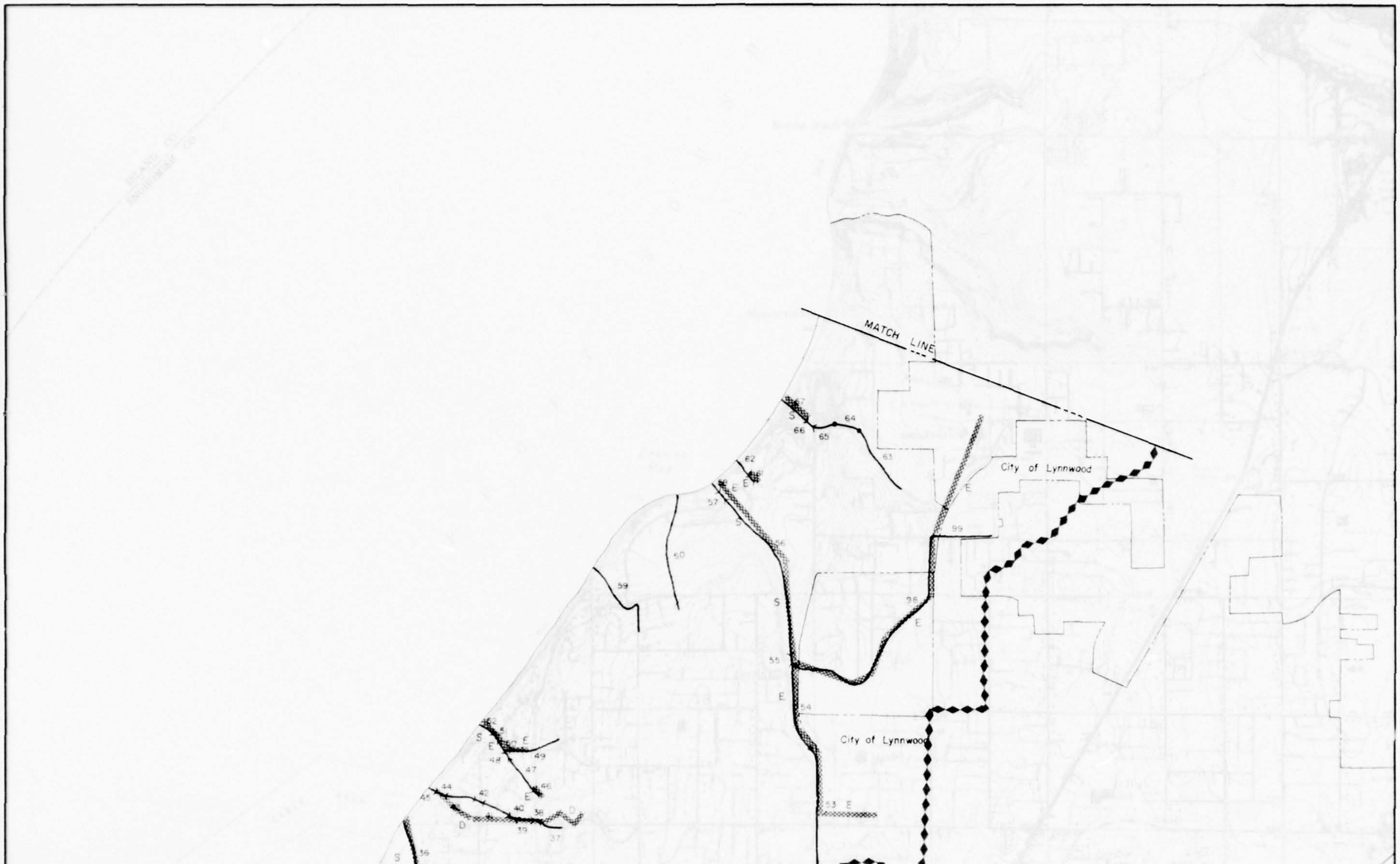
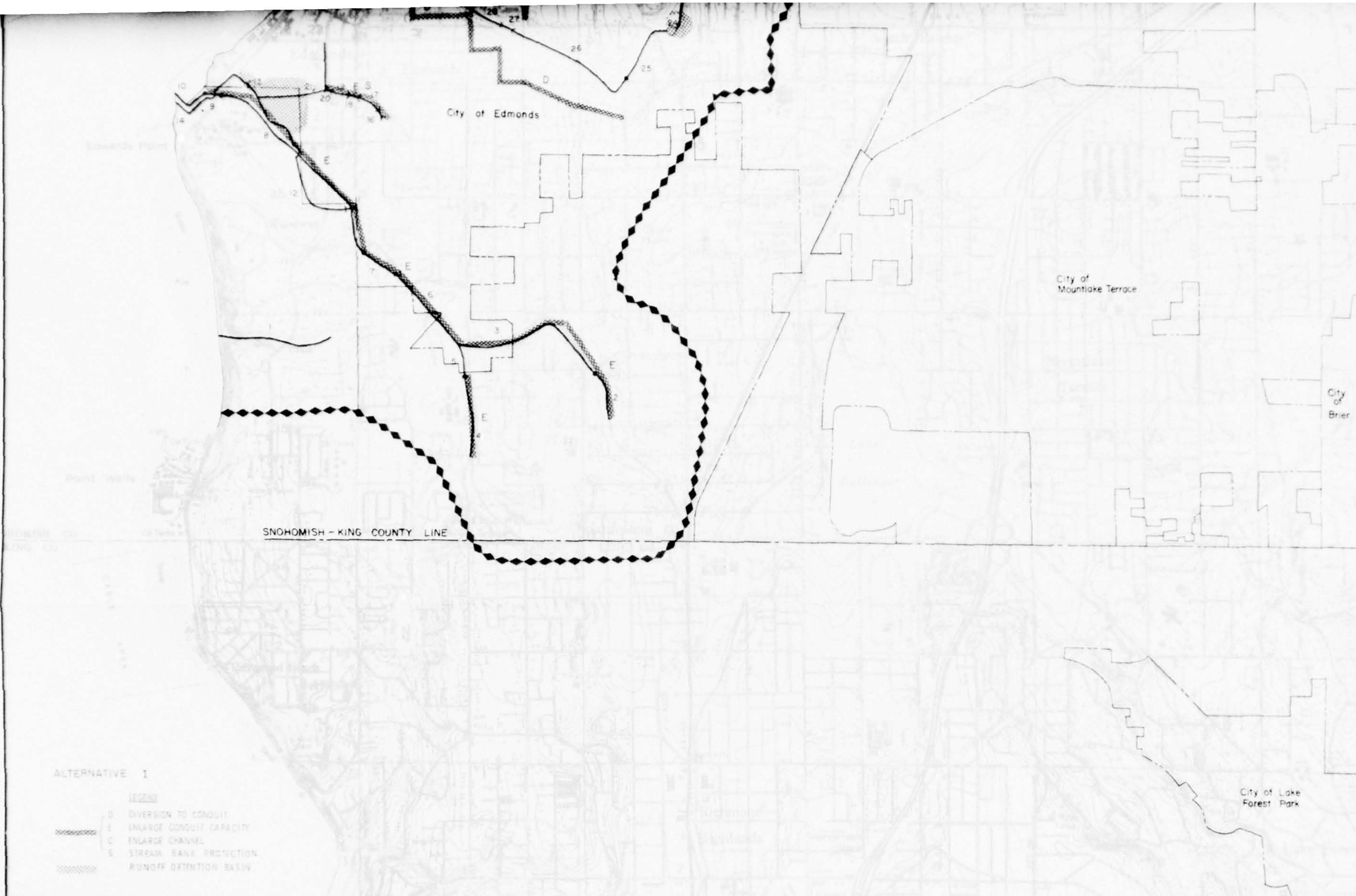
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1b OF 2



MATCH LINE
City of Lynnwood
City of Lynnwood
City of Edmonds
Edwards Point



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CORPS OF ENGINEERS
SEATTLE, WASHINGTON

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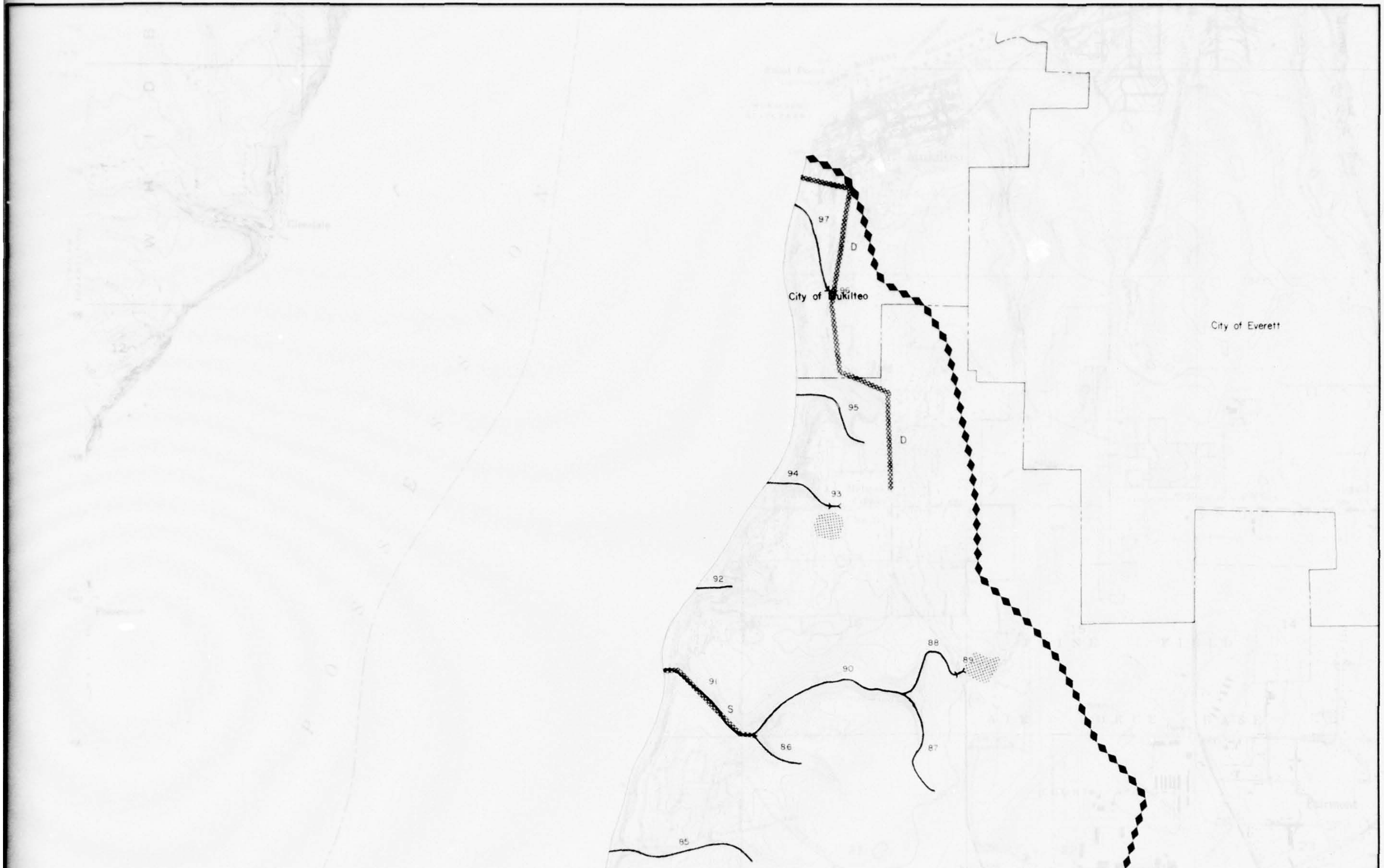

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City of Mukilteo
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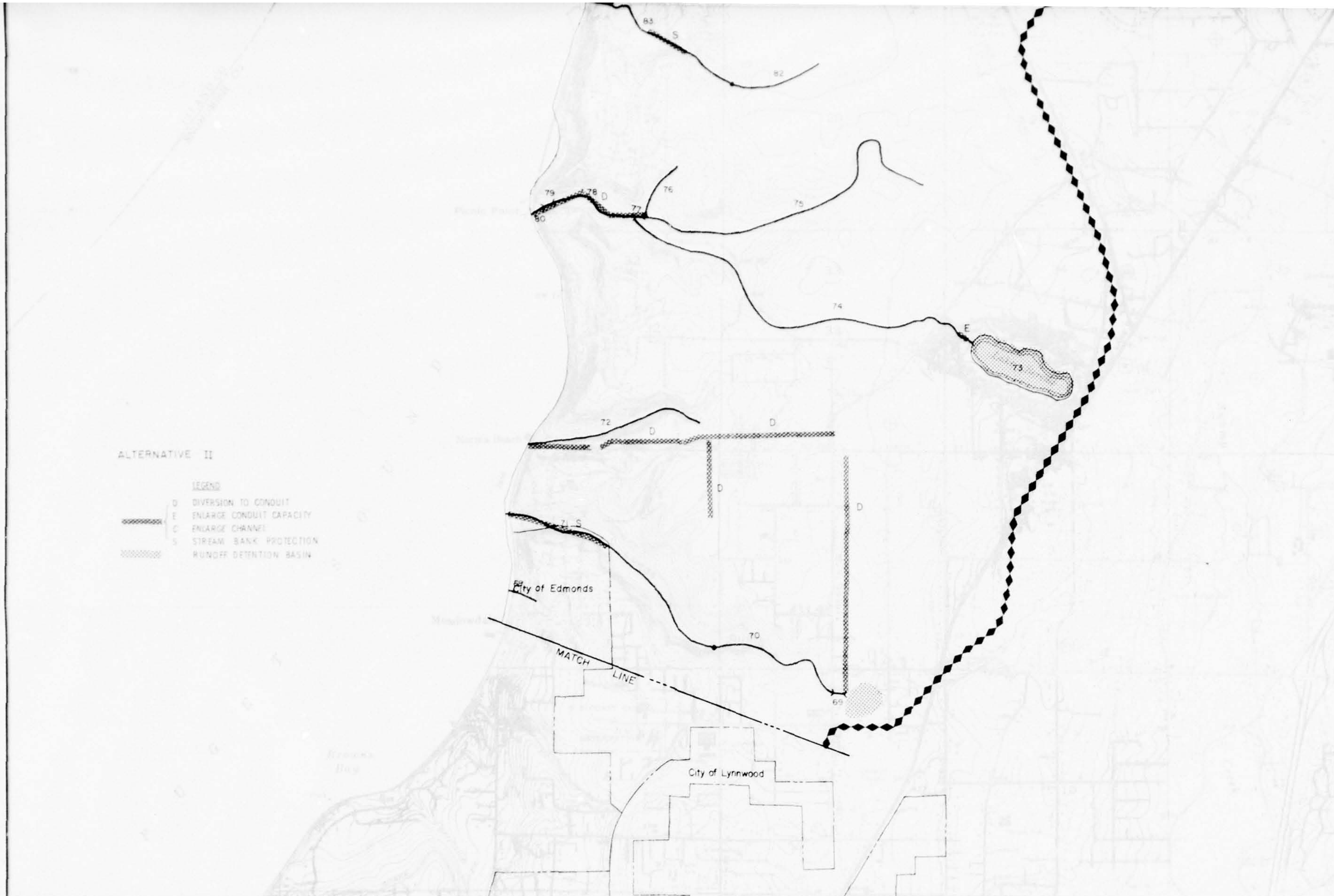

NO	DESCRIPTION	DATE	APPROVED

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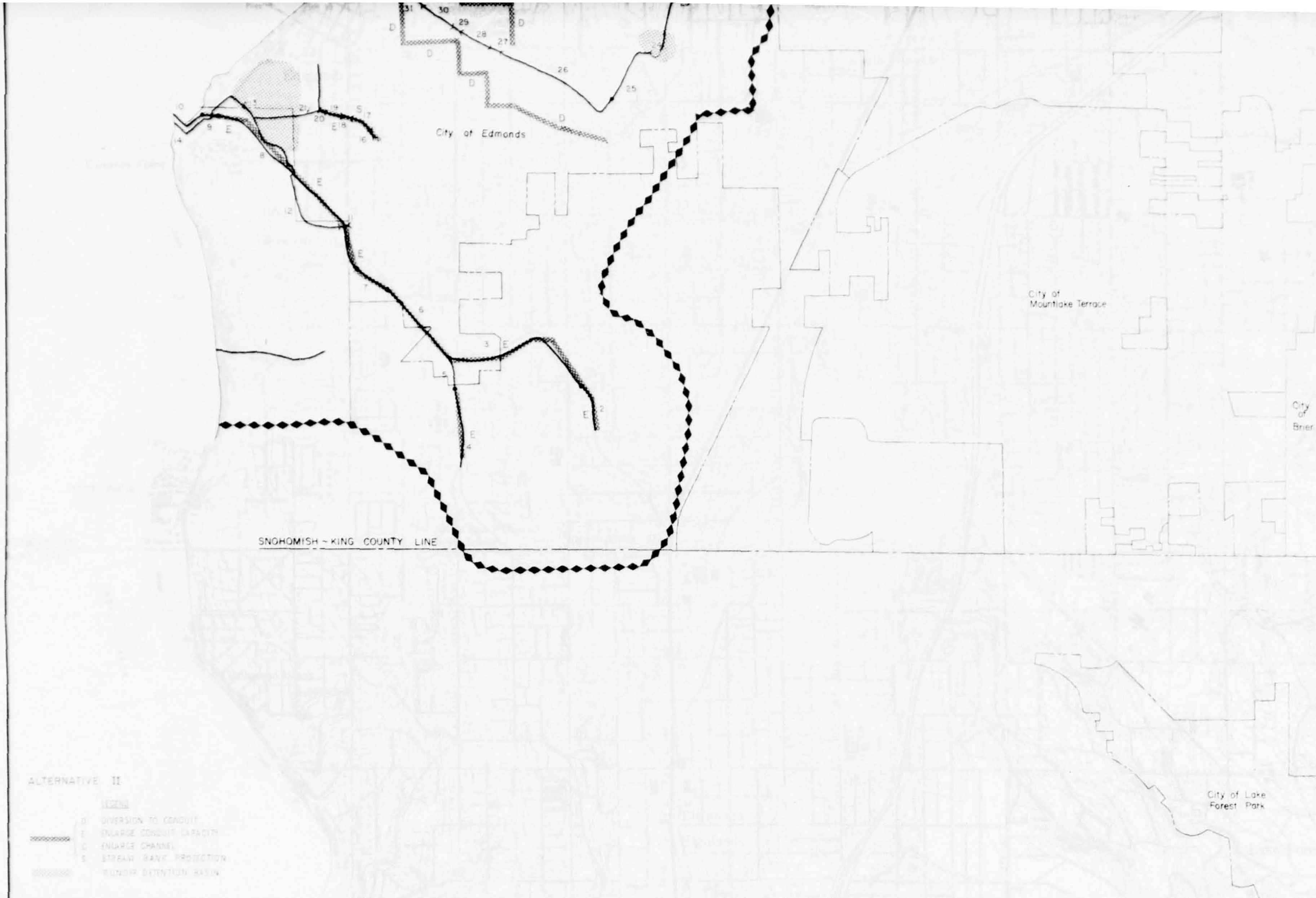
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1C OF 2


MATCH LINE
City of Lynnwood
City of Lynnwood
City of Edmonds



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SUB-BASIN BOUNDARY
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COUNTY (METRO) BOUNDARY
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HOLDING POND OR LAKE

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MILES

FEET

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REVISIONS

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CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2 OF 2

2

REGIONAL SUB-BASIN P-2

MIDDLE PUGET SOUND

GENERAL DESCRIPTION

The Middle Puget Sound Sub-Basin area generally can be described as a strip of land approximately one mile wide and 12 miles long, that extends south from the King-Snohomish County line to Magnolia Bluff and the U. S. Naval Reservation on Elliot Bay. The area encompasses such landmarks as Fort Lawton, Carkeek Park, and the Seattle Country Club. The topography of this area can be classified as steep; slopes are almost vertical along Magnolia Bluff. The highest point in the sub-basin is approximately 500 feet above sea level in the vicinity of Shoreline Community College.

The beaches in this sub-basin are a valuable resource for the urban community as a whole and contain several miles of clam beds and a waterfowl gathering place. Much of the shoreline is used for recreational purposes, including boating facilities at the Shilshole Marina, open beach facilities at Carkeek Park and a pathway along the Burlington Northern Railroad track that runs along the entire perimeter of the beach north of Salmon Bay.

Land use in the sub-basin varies from dense, single-family residential along the eastern divide of the sub-basin, to light residential development in the Highlands. The Metro Sewage Treatment Plant is situated at West Point south of Shilshole Bay and an oil-storage facility occupies a portion of the beach at the northern end of the basin. Land within the basin will continue to be primarily residential in nature with the greatest growth occuring in the relatively open areas in the north end.

A summary of land use within the sub-basin is presented below.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection	
		Comprehensive	Corridor
Single Family	55	71	67
Multiple Family	5	6	7
Commercial/Services	5	5	5
Govt. and Educ.	10	3	5
Industrial	4	5	5
Parks/Dedicated Open Space	5	4	5

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Agriculture			
Airports, Railyards, Freeways, Highways	< 1	<1	<1
Unused Land	15	5	5
Water	< 1	<1	<1
Total	100	100	100
Total Impervious Area	40	45	45

There are a number of jurisdictions in the sub-basin. The greatest area lies within the City of Seattle with smaller areas within unincorporated King and Snohomish Counties. The jurisdictional breakdown in percent of the total basin is Snohomish County 5%, King County 40%, and City of Seattle 55%. Also, the area is almost entirely within the Metro boundaries. In fact, three of Metro's five sewage-treatment facilities lie within the boundaries: the West Point Treatment Plant, Richmond Beach Treatment Plant, and the Pipers Creek System which discharges to Pipers Creek about 2,500 feet upstream from the beach. The other plants discharge through deep-water outfalls to Puget Sound.

NATURE OF EXISTING DRAINAGE SYSTEM

Because most of this sub-basin is highly developed, there is little drainage through natural channels. Pipers Creek, which runs through the center of Carkeek Park, and Boeing Creek in the north end of the sub-basin, are the only natural creeks of significant value, and their drainage boundaries primarily include residential areas. The physical characteristics of these two creeks are as follows:

Stream	Category	Drainage Area	Discharge
Pipers Creek	III	2.1 sq. mi.	Puget Sound
Boeing Creek	III	2.9 sq. mi.	Puget Sound

In the Pipers Creek basin, the City of Seattle has just completed a series of check dams through Carkeek Park and Pipers Creek. Carkeek Park is a relatively heavily used park and is a pleasant part of an otherwise urban environment.

There are a number of other open channels that discharge to Puget Sound, but they are fairly small drainage areas. The remainder of the area is served by storm sewers that outfall on the beach or into

one of the open channels. For Pipers Creek the City of Seattle has just completed a storm-sewer improvement project that has succeeded in collecting runoff from the residential areas in the upper end for discharge to the Pipers Creek ravine about three miles upstream from the beach.

DRAINAGE PROBLEMS

Sub-basin drainage problems are scattered. Slides have caused some concern along Magnolia Bluff. In the streets of the commercial districts that are low in the sub-basin, and in the upper residential areas, some flooding and ponding has been recorded.

Of greater importance in this sub-basin, however, is the impact of heavy runoff, created by development in the uplands, upon the two remaining natural creeks. In Pipers Creek, this impact has been especially noticeable. Erosion of the creek beds, because of increased and uncontrolled discharge to the ravine, has caused erosion and sedimentation and the formation of a considerable delta along the beach. In an attempt to halt this erosive action, the City of Seattle has constructed a series of check dams in the channel to slow velocities. A check-dam system was used instead of a drain line to the Sound primarily to maintain the natural beauty of the ravine. The full effect of these check dams for controlling erosion has not been fully evaluated, but with the completion of the storm-sewer improvements that discharge to the creek at its source, the concept of a dam system will be put to a rigorous evaluation.

One problem that occurs in the sub-basin, which results in more of a nuisance than in any physical damage, is that of flooding upstream of the culverts on Pipers Creek. The cause of the problem appears to be debris clogging the four large culverts under the railroad track and the trash rack immediately before it. Because this is a maintenance problem rather than a structural problem, and the inundated land is limited to low wetlands within the park boundaries, no correction action is needed.

Boeing Creek has problems comparable to those of Pipers Creek, largely because of development along Aurora Avenue. Flooding problems are due to the fact that upstream development has caused greater runoff than the creek channel can accommodate.

The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Plans. Therefore, the drainage alternatives presented herein are applicable to both plans.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

Existing planning in the area includes: 1) a Comprehensive Plan for King County, prepared in 1964, that describes policy and projected

land use for areas within the county, but does not present solutions to any specific problems; 2) a Comprehensive Drainage Plan for the North City Area, prepared by the County in 1967 that describes proposed pipe systems for various districts but covers only a small portion of the northern end of this sub-basin; and 3) an Urban Trails Plan, developed by the King County Planning Department in 1971, that illustrates the routes of proposed trail systems throughout the county. The plan calls for a trail system along the beach that follows the Burlington Northern right-of-way and interconnects with a trail from the Shoreline area. South of Salmon Bay, a beach trail, around Fort Lawton from the Aurora Bridge to Pier 91, is proposed.

A plan was prepared by the City of Seattle for Pipers Creek which eventually led to construction of a storm-sewer system that discharges into the ravine, and a system of check dams in the creek. King County is now developing a plan for solving erosion problems in Boeing Creek that incorporates dredging out silt-ladden Hidden Lake and restoring a portion of the creek upstream through the use of drop structures and channel repair. No formal study has been undertaken to date for the entire drainage sub-basin.

Staff members from King County Public Works Department, Hydraulics Division, reviewed the initial alternative plans. Officials from the City of Seattle and Snohomish County were not involved because there either were no problems in their portion of the sub-basin or the major problems had already been solved.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Middle Puget Sound Sub-Basin, as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to year 2000 land use. Drainage problems thus identified were analyzed and possible solutions provided in development of alternative plans for drainage control as described below.

Two major alternative plans were developed for solution of the Middle Puget Sound drainage problems. The first provides enlarged culverts, a diversion along the major portion of Boeing Creek and some streambank protection, and the second mostly provides stream-bank protection, enlargment of some culverts and use of two small holding ponds in the upper portion of the Boeing Creek watershed. A description of these two alternatives follows.

ALTERNATIVE PLAN I

General Concept

Alternative I approaches urban drainage in the conventional manner. Where present systems are inadequate to handle future flows,

parallel pipes have been provided. Protection of Boeing Creek is accomplished through storm sewers, but for Pipers Creek, where the City of Seattle already has implemented a check dam system, no further work is projected for the future.

Major Features

The largest single project in this sub-basin entails the construction of a diversion storm trunk line paralleling Boeing Creek. The line would protect the creek from the presently severe erosion that is occurring during heavy rainfall. The diversion line would allow nominal flow in the creek to maintain the natural stream environment but peaks for all but unusual storms would be held to a minimum.

Other elements of this alternative include construction of parallel storm sewers and increased capability for a number of culverts.

Cost

The estimated cost for the work included in this alternative is $2,460,000. This cost figure assumes the comprehensive land-use patterns for the year 2000. Under the corridor concept, there would be slightly more impervious land with the need for slightly larger drainage facilities and, consequently, a greater capital cost. The facilities for the corridor plan are estimated to cost $2,400,000 but because the recommended trunk lines for both plans differ so slightly the corridor plan is not recorded in this description.

ALTERNATIVE PLAN II

General Concept

Except for the Boeing Creek drainage area, Alternative Plans I and II are identical; they both would provide parallel pipes for systems with presently inadequate facilities. For the Boeing Creek Alternative Plan II, holding ponds with subsequent controlled release, and protection of the stream with rip-rap and drop structures to reduce flow velocities and minimizing erosion, were included.

Major Features

As with Alternative Plan I, the major features in this plan would be found in the Boeing Creek drainage area. These features would include three holding ponds, one in the commercial area east of Aurora Avenue, one in the north end in Kings Garden, and the last at Hidden Lake. Check dams, cascades and rip-rap would be built on Boeing Creek to protect its banks and all control structures would be designed to hold discharge rates to the creek to nominal amounts except during extreme rainfall conditions.

Other elements of this alternative include construction of parallel storm sewers and increasing the capability of a number of culverts.

Cost

The estimated cost for the improvements in this alternative plan is $1,300,000 or about 50% less than Alternative Plan I. As before, this is for the comprehensive land use concept; for the corridor plan the capital cost would be about 2% greater.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and with alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
Boeing Creek	300	50	250
Boeing Creek Diversion	0	600	---
Pipers Creek	450	450	450
N.W. Neptune Place	85	100	100

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternatives in this sub-basin. This process was followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements.

The various structural solutions were checked against the appropriate criteria. The various non-structural solutions were reviewed for their relationship to existing and probable future developments. Criteria rating for Alternative Plan I, which employs enlargement of many conduits, some streambank protection and a diversion along much of Boeing Creek, was a minus 21 out of a possible range of a positive total of 108 and a negative total of 108. The total evaluation rating for Alternative Plan II, which employs streambank protection, enlarge-

ment of culverts, and some holding ponds in the upper areas of Boeing Creek, was a plus 8. Both alternative plans were judged to be effective for controlling drainage. Both plans involved sacrifices of human value and human uses of the land once they were built. Environmentally, Alternative Plan II offered more resource-preservation potential than Alternative Plan I, which required a diversion line along a large portion of lower Boeing Creek and a large amount of serious excavation work. Neither alternative is part of present planning for any of the involved agencies, and therefore extensive cooperation on their parts is required. However, a great majority of the construction will need to be done within King County. Both of the alternative plans involve commitments of the use and management of natural resources because they rely upon certain structural treatments for all or part of their solutions. Therefore, neither alternative can be said to be clearly superior to the other in this concern.

Alternative Plan II makes use of holding ponds and requires dredging of the silt-ladden Hidden Lake for use as a holding pond. This alternative is quite amenable to supplemental land uses, such as park and recreation use. The holding ponds also have a small effect in raising the groundwater level.

Neither Alternative Plan I or II relies upon either flood-plain zoning or runoff control for future land development. Streambank erosion is a serious problem at several points along Boeing Creek and action should be taken in the near future to alleviate this problem.

CONCLUSIONS

Alternative Plan I is a direct approach to the solution of problems in the Middle Puget Sound Sub-Basin, but it is not the most economical means available. The diversion line around Boeing Creek will be both costly and difficult to construct, especially in one area where trench excavation could exceed 25 feet. Although certain of providing relief to erosion problems, the cost of this plan makes its implementation somewhat tenuous. One approach for the diversion line around Boeing Creek would be to implement Alternative Plan II and construct facilities in phases beginning with the channel protection, and followed by an evaluation of the effectiveness of that work prior to the commitment of any further funds. Alternative Plan II is considerably less costly than Alternative Plan I and presents the advantage, at least for the problems in Boeing Creek, of being amenable to phased construction. Phase I could include channel improvements to be followed by the development of storage facilities and trunk lines. The total storage provided could be balanced against the effectiveness of the channel protection once a determination was made of the flow that Boeing Creek could handle in its improved condition. The other improvements in the sub-basin could be constructed in an independent schedule. It should be recognized here that the largest portion of the storage costs are for land purchase, and the land could be leased or used for

a multiple purpose such as recreation or open space. Capital costs could be reduced or shared among several agencies that would benefit from the use of the land when it is not inundated.

From the standpoint of cost-effectiveness, Alternative Plan II is superior to Alternative Plan I for the latter also presents a less conventional and hence more risky approach.

Both Seattle and King County should have responsibility for control of drainage within their respective jurisdictions. Each of the drainage systems within the Middle Puget Sound Sub-Basin is independent and, therefore, better coordination would be necessary to implement a drainage program.

RUNOFF QUALITY SUMMARY
MIDDLE PUGET SOUND

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
	2000 Comprehensive Land Use						
Boeing Creek	I	600	22	1.3×10^5	.5	1.4	.1
	II	250	22	1.3×10^5	.5	1.4	.1
Pipers Creek	I	450	9	1.7×10^5	.2	.6	.1
	II	450	9	1.7×10^5	.2	.6	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

MIDDLE PUGET SOUND

ALTER- NATIVES	SUB TOTAL	EFFECTIVENESS								SUB TOTAL	HUMAN VALUES							SUB TOTAL	ENVIRONMENTAL FACTORS									SUB TOTAL	IMPLEMENTATION						SUB TOTAL	RESOURCE REQUIREMENTS				RATING TOTAL
		Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking		Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety		High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation		Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action		Energy	Materials	Land	Capital	
		CRITERIA WEIGHT									CRITERIA WEIGHT								CRITERIA WEIGHT										CRITERIA WEIGHT							CRITERIA WEIGHT				
		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	+6									-3								-6										-8							-10					-21
II	+10									+4								+6										-8							-4					+8

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Middle Puget Sound

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
4	Pipe	21"	1,550'			Parallel Pipe	21"	$56,000
3	Pipe	24"	350'			Parallel Pipe	18"	$11,000
8	Pipe	24"	200'			Parallel Pipe	21" Includes inlet and outlet	$11,000
5	Pipe	24"	350'			Parallel Pipe	24" Includes inlet and outlet	$19,000
24	Pipe	24"	3,500'			Parallel Pipe	48"	$326,000
23	Pipe	24"	1,100'			Parallel Pipe	48"	$102,000
20	Pipe	48"	1,400'			Parallel Pipe	48"	$130,000
19	Pipe	48"	1,300'			Parallel Pipe	60"	$156,000
72	None		500'			Diversion Pipe	60" 500'	$60,000
73	None		2,000'			Diversion Pipe	96" 2,000'	$414,000
74	None		1,000'			Diversion Pipe	60" 1,000'	$120,000
75	None		1,200'			Diversion Pipe	72" 1,200'	$179,000
76	None		300'			Diversion Pipe	60" 300'	$36,000
77	None		200'			Diversion Pipe	48" Includes inlet and outlet 200'	$26,000
78	None		2,000'			Diversion Pipe	60" 2,000'	$240,000
79	None		1,200'			Diversion Pipe	60" 1,200'	$144,000
80	None		1,200'			Diversion Pipe	66" 1,200'	$162,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Middle Puget Sound

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
33	Pipe	30"	1,400'			Parallel Pipe	30"	$76,000
34	Pipe	27"	700'			Parallel Pipe	27"	$33,000
36	Pipe	24"	200'			Parallel Pipe	18" Includes inlet and outlet	$9,000
6	Channel	15'	2,500'	2:1	10'	Channel	Streambank protection	$20,000
9	Channel	6'	3,800'	2:1	10'	Channel	Streambank protection	$36,000
52	Channel	51'	2,500'	2:1	5'	Channel	Streambank protection	$11,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $2,377,000

Round To: $2,400,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Middle Puget Sound

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
4	Pipe	21"	1,550'			Parallel Pipe	21"	$56,000
3	Pipe	24"	350'			Parallel Pipe	18"	$11,000
8	Pipe	24"	200'			Parallel Pipe	21" Includes inlet and outlet	$11,000
5	Pipe	24"	350'			Parallel Pipe	24" Includes inlet and outlet	$19,000
20	Pipe	48"	1,400'			Parallel Pipe	24"	$59,000
23	Pipe	24"	1,100'			Parallel Pipe	30"	$59,000
19	Pipe	48"	1,300'			Parallel Pipe	36"	$86,000
33	Pipe	30"	1,400'			Parallel Pipe	30"	$76,000
34	Pipe	27"	700'			Parallel Pipe	27"	$33,000
36	Pipe	24"	200'			Parallel Pipe	18" Includes inlet and outlet	$9,000
18	Channel	6'	2,000'	2:1	10'	Channel	Drop structure channel restoration and bank protection	$64,000
10	Channel	4'	700'	2:1	7'	Channel	Drop structure channel restoration and bank protection	$14,000
14	Channel	6'	1,300'	2:1	5'	Channel	Drop structure channel restoration and bank protection	$29,000
12	Channel	10'	1,100'	2:1	5'	Channel	Drop structures and bank protection	$25,000
11	Channel	20'	2,500'	2:1	20'	Channel	Drop structures and bank protection	$52,000
85	None					Holding Pond	7AF	$150,000
86	None					Holding Pond	6AF	$202,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

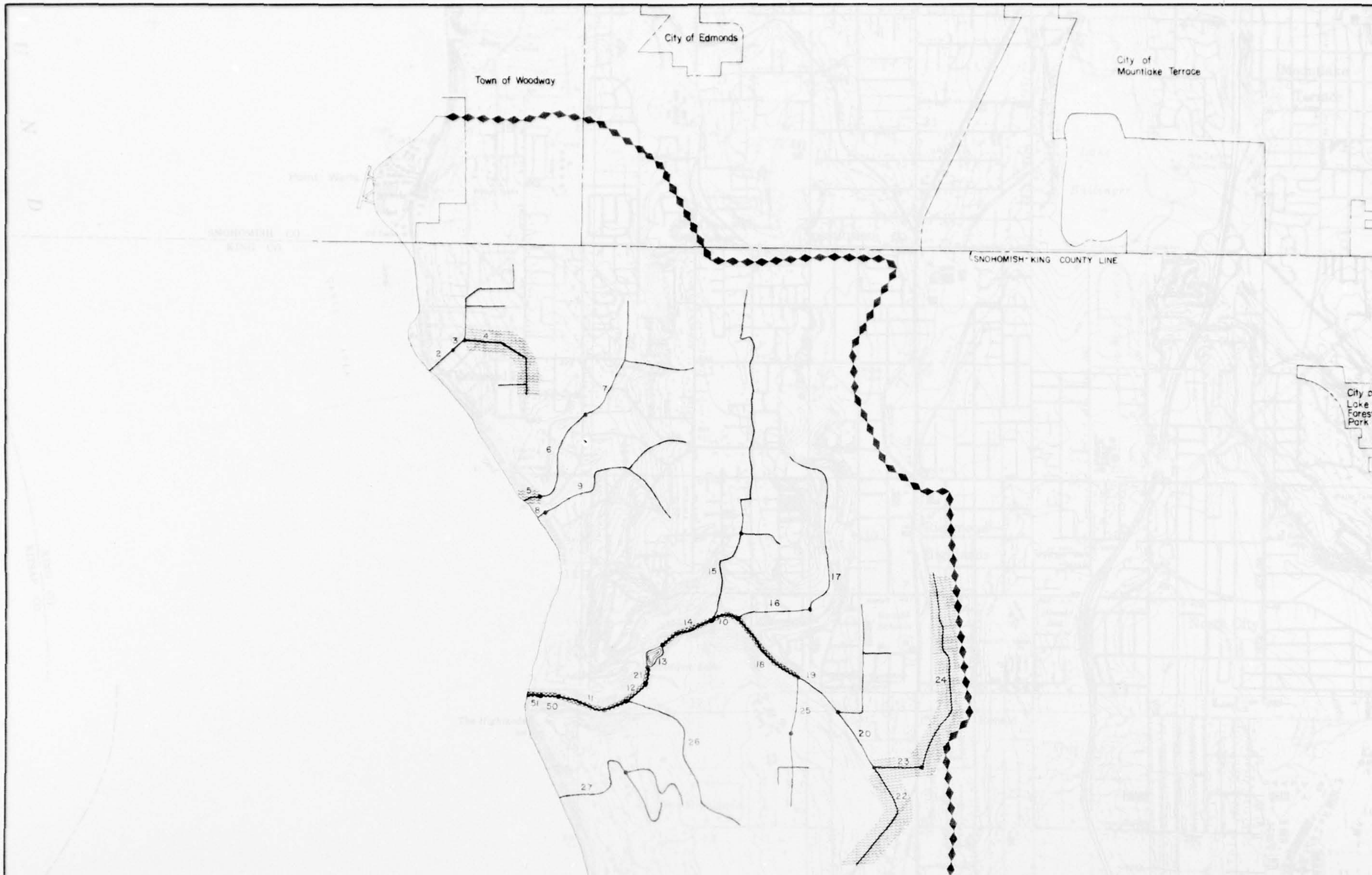
Alternative II   Sub Basin Middle Puget Sound

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
13		Hidden Lake				Holding Pond	16AF	$239,000
6	Channel	15'	2,500'	2:1	10'	Channel	Streambank protection	$20,000
9	Channel	6'	3,800'	2:1	10'	Channel	Streambank protection	$36,000
52	Channel	5'	2,500'	2:1	5'	Channel	Streambank protection	$11,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $1,261,000

Round To: $1,300,000


Town of Woodway
City of Edmonds
City of Mountlake Terrace
SNOHOMISH-KING COUNTY LINE
City of Lake Forest Park
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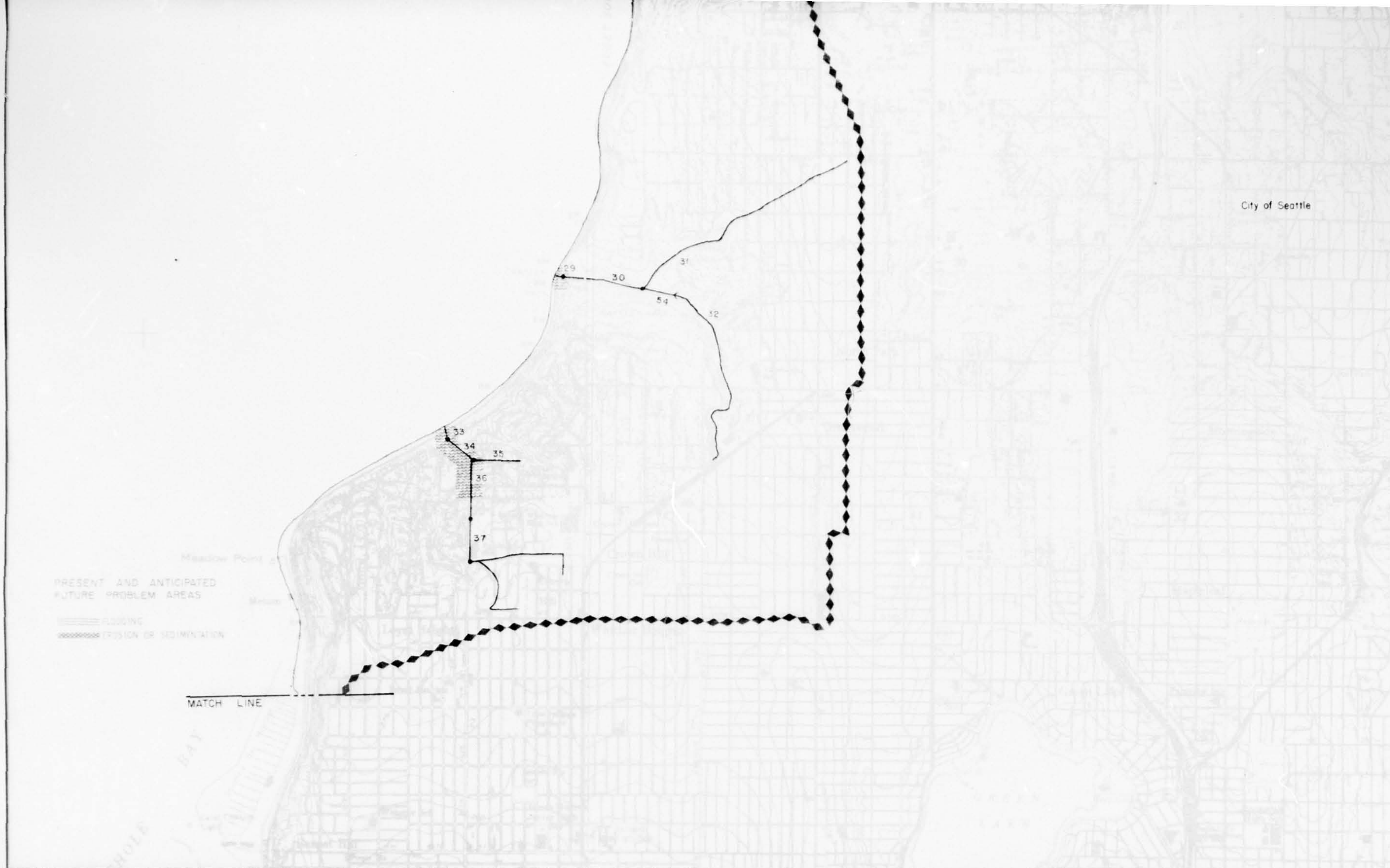


LEGEND

SUB BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE INLET OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

N

MILES

FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MIDDLE PUGET SOUND

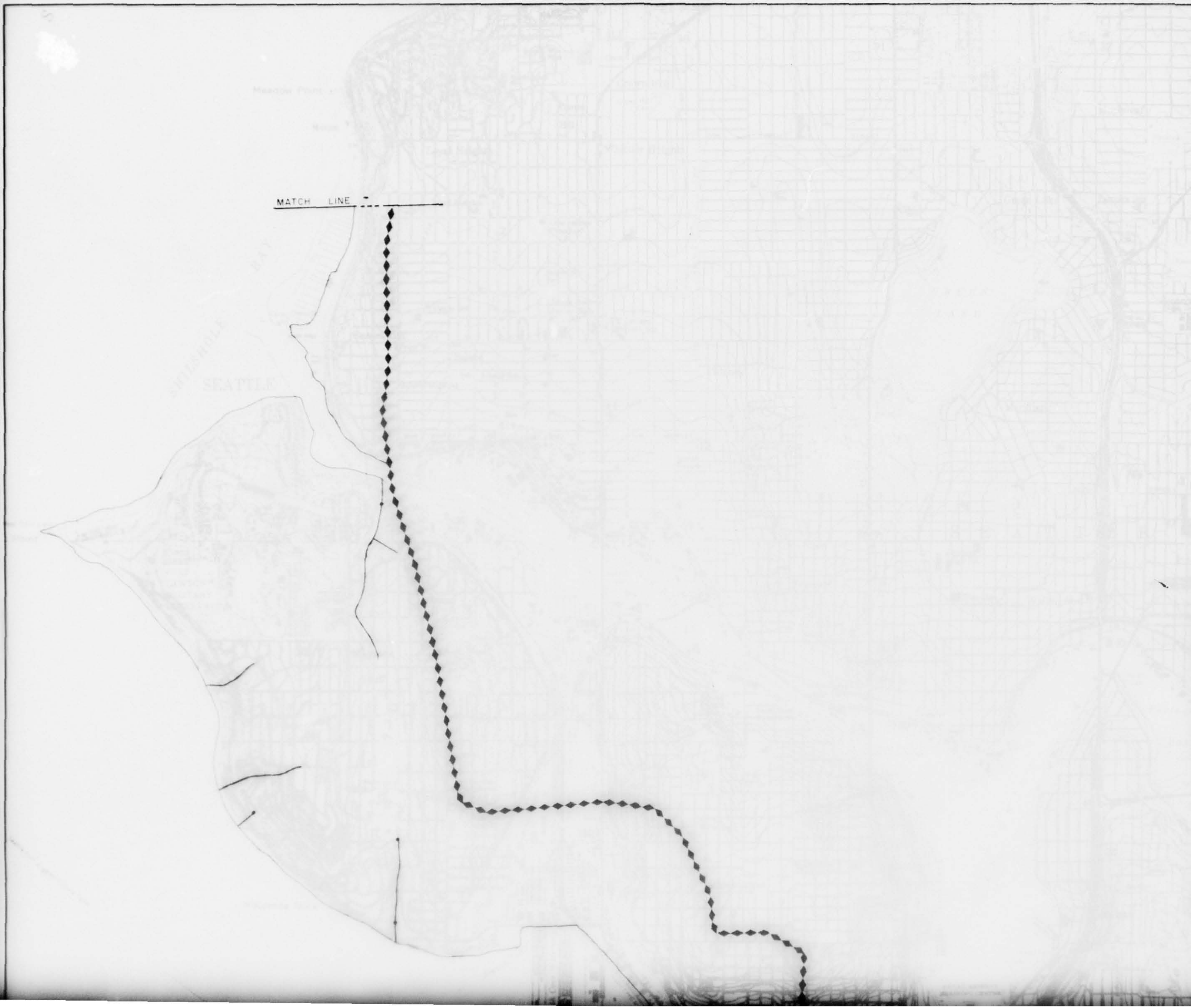
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1 OF 2

2


MATCH LINE
SEATTLE
BAY

LEGEND

- SUB-BASIN BOUNDARY
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- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

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FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MIDDLE PUGET SOUND

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
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CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE ________ FILE NO E-26-1-161 SHEET 2 OF 2

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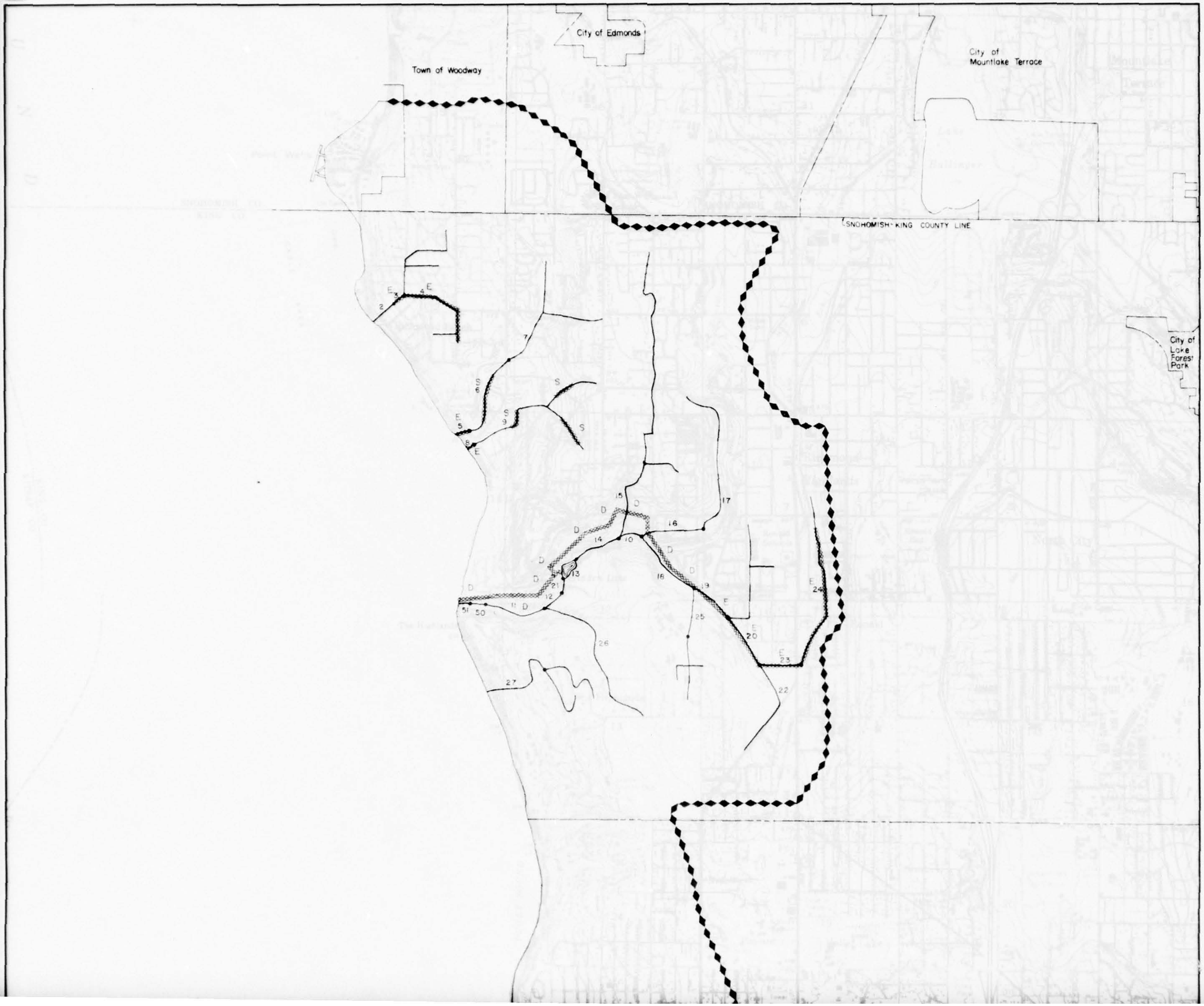
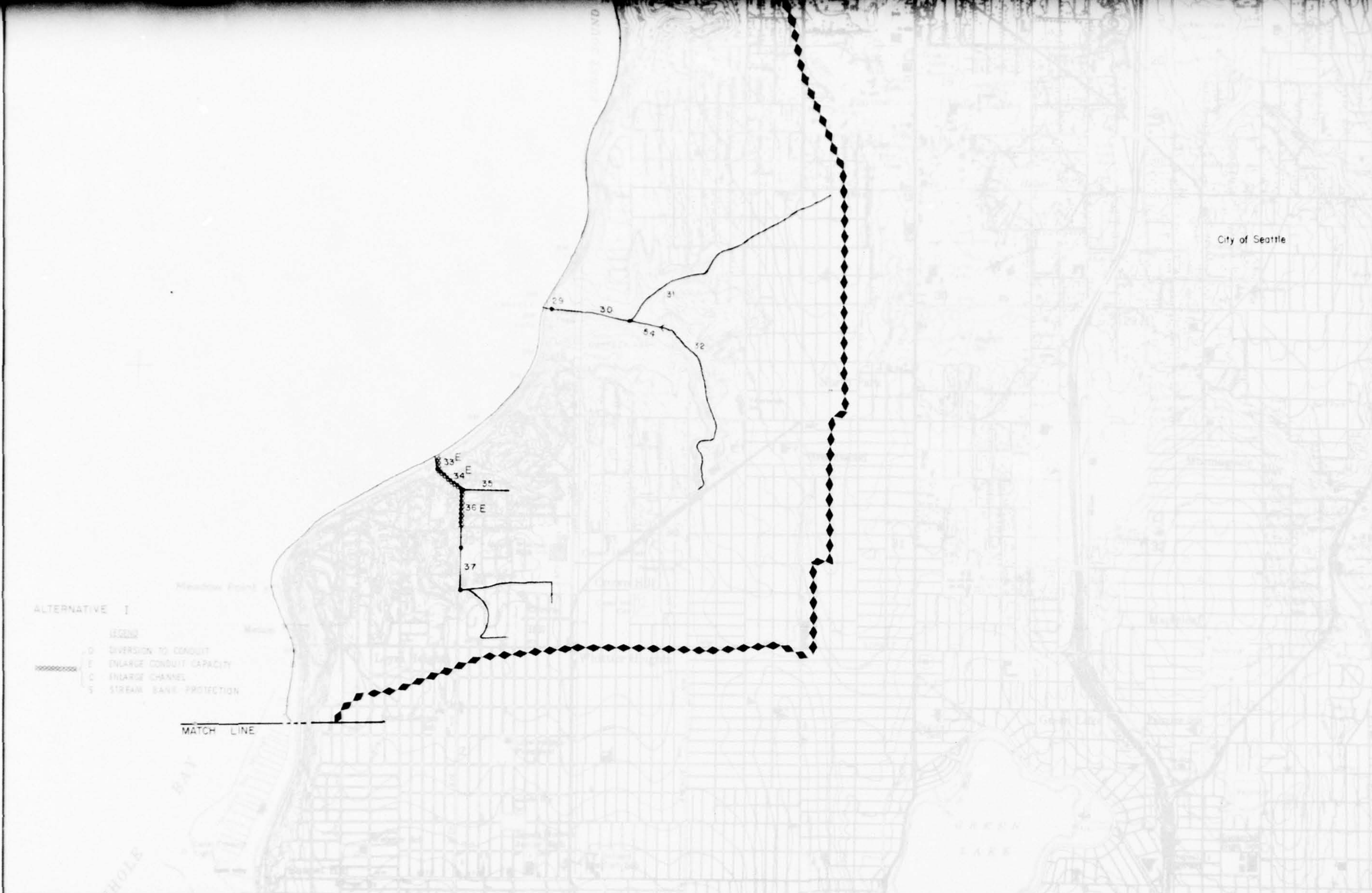


Town of Woodway
City of Edmonds
City of Mountlake Terrace
SNOHOMISH-KING COUNTY LINE
City of Lake Forest Park



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

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FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MIDDLE PUGET SOUND

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1b OF 2

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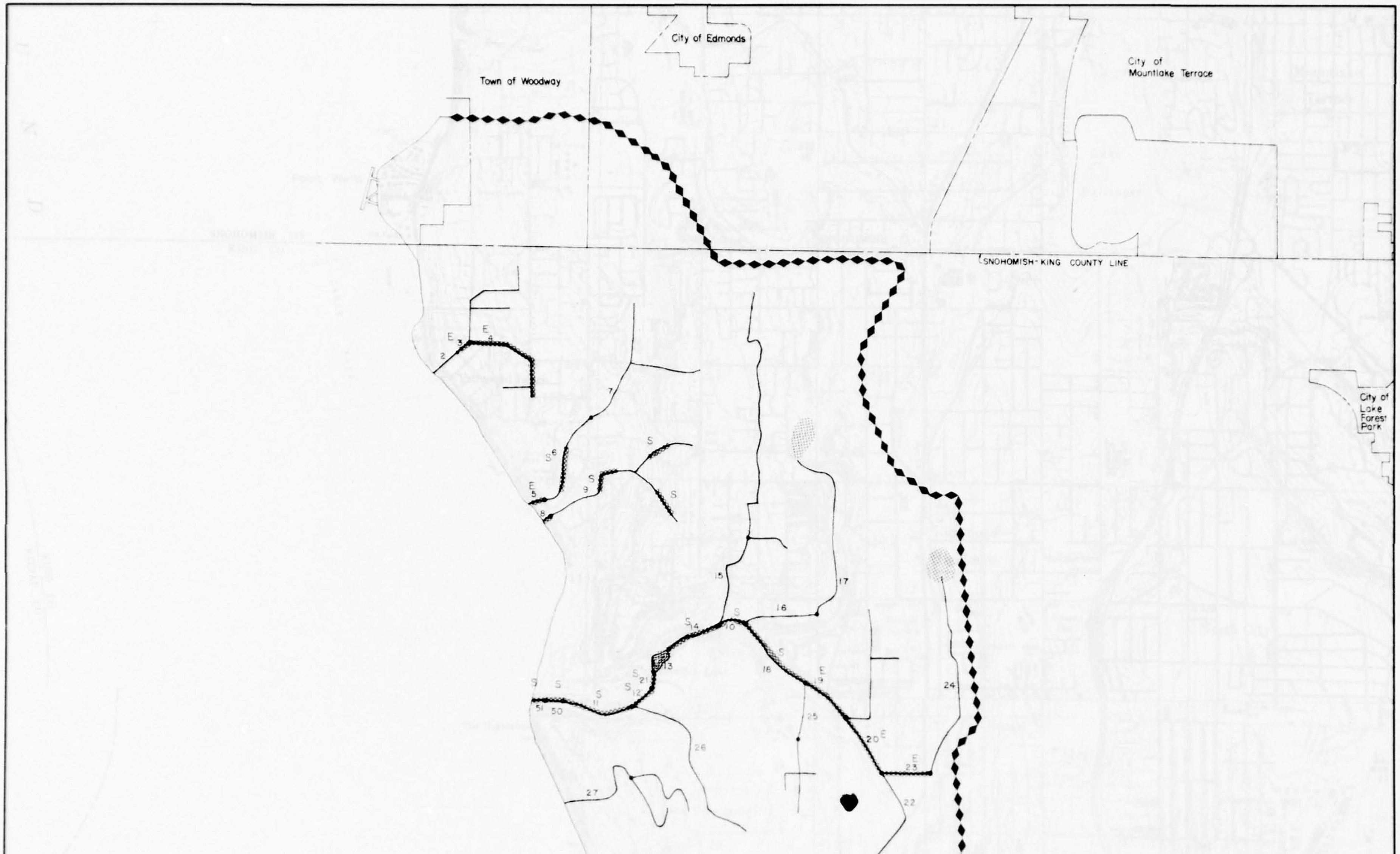
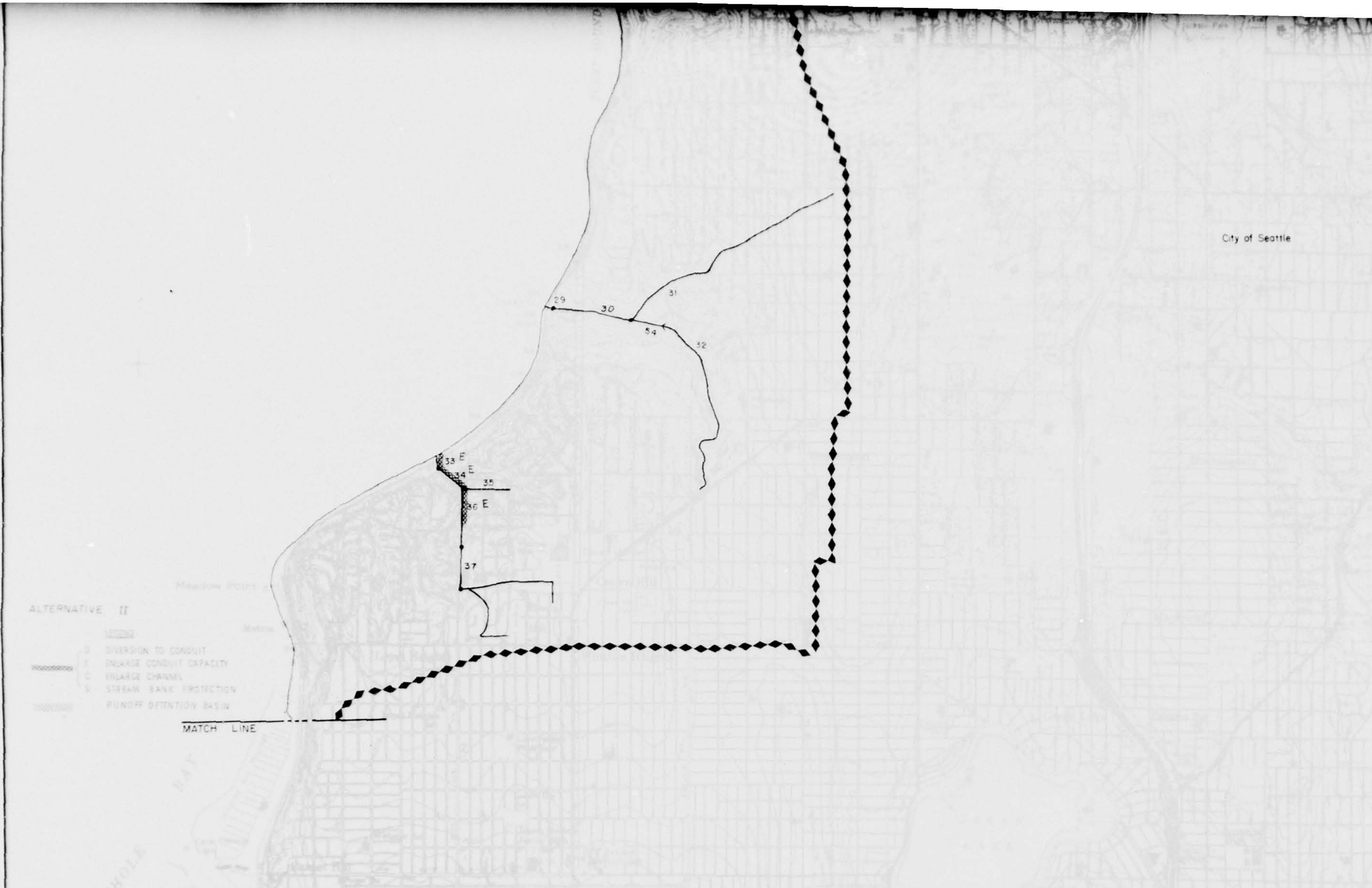


City of Edmonds
Town of Woodway
City of Mountlake Terrace
SNOHOMISH-KING COUNTY LINE
City of Lake Forest Park



LEGEND

SUB BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE INLET OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

MILES 1/2 1/4 0 1

FEET 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

MIDDLE PUGET SOUND

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
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U.S. ARMY ENGINEER DISTRICT, SEATTLE
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SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 11 OF 2

REGIONAL SUB-BASIN P-3

LOWER PUGET SOUND

GENERAL DESCRIPTION

The Lower Puget Sound Sub-Basin is located adjacent to Puget Sound, and it extends 19 miles south from Elliot Bay (Seattle) to Poverty Bay. The sub-basin width varies between one mile and three miles, the watershed boundary is delineated along the plateau crestline that exists between the major geographical features of Puget Sound and the Duwamish River.

Most streams within the sub-basin flow westerly into Puget Sound or flow into natural land sinks to form lakes and bog-marsh areas.

The geography of the sub-basin is variable. The sub-basin itself is basically a plateau area, with eroded valleys along the seaward side that were created by overland flow. The sub-basin also has numerous land sinks or depressions, an ancient glacial feature that is predominate throughout the Puget Sound area. The sub-basin itself has boundaries delineated primarily by natural features, such as hill crest lines and saddles. Where the sub-basin boundary passes through urbanized areas, man-made features (street gutters, etc.) align the watershed boundary.

There are numerous streams that flow into Puget Sound and/or the natural sinks within the sub-basin. Of these, two major streams drain the mid-upper portion (Miller Creek) and the mid-portion (Des Moines Creek) of the drainage basin.

Stream	Category	Drainage Area	Discharge
Miller	III	8.9 sq. mi.	Puget Sound
Des Moines	III	5.8 sq. mi.	Puget Sound

Miller Creek may be considered a floodway zone throughout most of its reach, with a pastoral zone in the upland bog and marsh areas. This creek drains from Arbor Lake southerly to Tub Lake, then southwesterly to its outflow into Puget Sound. The drainage area is approximately nine square miles and the stream extends throughout its entire length. Principal features of the Miller Creek sub-area are the Burien Commercial area, Sea-Tac Airport, and the highway system SR509 and SR518. There is no gaging station for this stream, and its change in elevation is about 400 feet as measured from the Arbor Lake area to Puget Sound. The Miller Creek drainage basin has been designated as a RIBCO demonstration area, and is presented separately in this Appendix.

The second major stream in this sub-basin, Des Moines Creek, also can be considered a floodway zone stream. It drains from the Seattle-Tacoma Airport south and southwesterly to its outflow into Puget Sound.

Land-use development is tabulated below for existing conditions (1970-1972), and for the projected year 2000 Comprehensive and Corridor Land Use Plans. Single-family residential development is the predominant land use for all three categories. The projected trend will be for a 10-percent reduction in single-family units, and an increase in multiple-family 4%, retail 1%, industrial 2%, open land 3% and government and education 2%. All existing vacant land (2%) will be altered by development before the year 2000.

PERCENT OF SUB-BASIN AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection	
		Comprehensive	Corridor
Single Family	80	70	70
Multiple Family	1	5	5
Commercial/Services	5	6	6
Govt. and Educ.	2	.4	4
Industrial		2	2
Parks/Dedicated Open Space	5	8	8
Agriculture			
Airports, Railyards, Freeways, Highways	5	5	5
Unused Land	2		
Water			
Total	100	100	100
Total Impervious Area	35	40	40

Jurisdictions in the sub-basin are numerous, consisting of King County 40%, Port of Seattle 5%, City of Seattle 50%, City of Normandy Park 5%. Only the northern and central eastern portion of the drainage sub-basin is serviced by Metro. The districts of White Center, Des Moines, Redondo, Federal Way, and Burien are within the sub-basin.

Small special-interest groups and concerned individuals in the sub-basin have expressed interest in helping to plan future action to curb detrimental effects upon the natural streams such as water pollution and land erosion. One such citizen agency is the King County Environmental Development Commission. Another that is working with King County on drainage problems is the Miller Creek Drainage Basin Committee.

NATURE OF EXISTING DRAINAGE SYSTEM

The nature of the drainage systems are fairly similar throughout the entire sub-basin. This is due to the predominate land-use of single-family residences. There are several large lakes and numerous "pot holes" or sinks that act as storage ponds during wet weather. There are wetlands within the sub-basin, consisting of marshes and bogs in level lowlands and around lake perimeters that act to moderate runoff rates. As mentioned earlier, there are numerous streams that flow into either Puget Sound or land depressions.

Man-made facilities in the drainage system consist primarily of street culverts and storm sewers. There is a fish ladder in Des Moines Creek, and some lakes have outflow controls. Presently, the Port of Seattle, is constructing a large holding pond northwest of the Seattle-Tacoma Airport. For the most part, man-made drainage systems are incomplete and depend upon the natural system for final transport of storm-water. These partial systems often create erosion and water-quality problems.

It is quite obvious that within this predominately residential area, streams are important recreational and aesthetic assets. Some of the streams are used, in part, as dumps by thoughtless individuals in both residential and commercial areas. This careless action destroys a potentially valuable and attractive amenity in both the social and natural environment.

DRAINAGE PROBLEMS

Problems in the drainage sub-basin are numerous. In brief, the basic problems stem from the fact that urban development has been allowed to occur without regard for its impact upon the hydrologic process of the natural drainage system. Major problems are ponding, flooding near the streamway, sliding of unstable soils during wet weather, siltation of the natural drainage network, increase of surface-water runoff due to increased land development and percent of impervious surfaces (reduction of groundwater infiltration), and stream pollution due to dumping of commercial and residential sewer wastes. These problems have been identified by concerned individuals and by several research papers dealing with Miller Creek. (Miller Creek Watershed, by the Department of Landscape Architecture, University of Washington, September, 1973).

The Lower Puget Sound Sub-Basin has two major creeks, Miller Creek and Des Moines Creek, and several smaller streams. Miller Creek, located within the Lower Puget Sound Sub-Basin has been studied as one of the five RIBCO demonstration areas; therefore, Miller Creek has been excluded from this sub-basin.

The following discussion mostly pertains to Des Moines Creek, the second of the two major creeks in Lower Puget Sound, with additional comments about many other streamways. This description organization, which highlights Des Moines Creek, does not mean that the other streams and watersheds are of less importance.

The Lower Puget Sound Sub-Basin now is highly urbanized, with only a 2 percent unused land area. Both the 2000 Comprehensive and Corridor Plans indicate that the entire area will be urbanized by the year 2000. The existing drainage problems in this sub-basin will become more severe because of increases in impervious areas and faster runoff. The total impervious area in the sub-basin under either land use projection will increase from the existing 35% level to a level of approximately 40%, as shown in the table of projected land uses.

The results of hydrologic analyses in this sub-basin indicate no significant difference between the Comprehensive and Corridor Plans. Therefore the drainage alternatives presented herein are applicable to both plans.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

The four agencies that have urban drainage planning authority in the Lower Puget Sound Sub-Basin are King County, the Port of Seattle, City of Seattle, and Normandy Park. Presently, the Port of Seattle is conducting a study of Miller and Des Moines Creeks. The interim report, entitled "Sea-Tac Communities Plan Interim Report 52, Water Quality Analysis," investigated water quality, biological conditions, and hydrologic capacities of the two streams. No planning recommendations were presented. The final report will be issued in June.

Presently, King County has a comprehensive drainage plan for Miller Creek that has been stopped by a citizen suit due to concern over environmental damage.

During November, 1973, a RIBCO community meeting was held in Burien to discuss various alternative methods to alleviate flooding in Miller Creek and adjacent streams. Five general alternatives were presented and they include the following: 1) Continuation of present trends, 2) storm water diversion facilities, 3) flood-plain management, 4) channelization, and 5) watershed management. Of the five alternatives presented, watershed management was preferred, followed by stormwater diversion facilities.

Staff members from the King County Public Works Department, Hydraulics Division, and citizens from the RIBCO Stream Advisory Committee have jointly reviewed the initial alternative plans for drainage developed by this RIBCO Study for the Lower Puget Sound Sub-Basin.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Lower Puget Sound Sub-Basin as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to the year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in development of alternative plans for drainage control as described below.

Two major alternative plans were studied for solving the Lower Puget Sound drainage problems. The first consists primarily of two elements, holding ponds and a diversion pipeline, and the second is identical to concept one except for one major addition which is land use control in the Des Moines watershed. Their description follows.

ALTERNATIVE PLAN I

General Concept

This concept is one that deals primarily with holding ponds, diversion pipelines and a certain amount of streambank protection. No future land use controls to restrict runoff would be required in this alternative.

Major Features

From computer model simulation of Des Moines Creek, flooding begins just below Bow Lake and progresses downstream. To alleviate flooding the first of two major holding ponds was created at Bow Lake. One other holding pond also used in this concept was located near the end of the runways at Sea-Tac Airport. Location of the holding ponds was selected so that they occurred in natural wetland depressions, were distant from major residential areas and were located near roads to facilitate ease of construction, operation and maintenance.

For the excess flows that the holding ponds cannot contain, a diversion pipeline concept was used with the downstream channels. In this manner, flow exceeding the natural flow of the channel is diverted into a parallel pipeline which conveys the flow until the creek has a large enough capacity to handle its present flow plus that of the diverted flow. At this point, the diversion pipeline directs the flow back into the creek. This concept has the advantage of preserving the natural stream as it does not require enlarging or rip-rapping it.

The diversion from the west into Bow Lake is for storage purposes. The 48-inch pipe at the south end of the second holding pond near the end of Sea-Tac runway should be throttled down so that only a limited amount (50 cfs) of its present flow rate capacity (100 cfs) is used.

In regard to the rest of Lower Puget Sound Sub-Basin, only diversion pipelines were used without any holding ponds to alleviate flooding. Streambank protection is also required for many areas of the Lower Puget Sound Sub-Basin and flood-plain zoning is required around and downstream from Arrow Lake.

Cost

The total estimated capital cost for this alternative plan is $8,700,000.

ALTERNATIVE PLAN II

General Concept

This concept is identical to Alternative Plan I except for one major addition which is land use control in the Des Moines Creek watershed, and a holding pond used with the Salmon Creek drainage system.

Major Features

The most significant feature of this alternative is that of land use control. Essentially, development is controlled so that runoff is limited to approximately the same runoff that would occur under present conditions.

Presently, King County has storm drainage policy for land development that states, "... drainage plans shall provide storm water retention facilities so that peak discharge from the site will not be increased by more than 25% due to the proposed development."

Even with this policy, holding ponds and a diversion pipeline will be required in this sub-basin.

The holding ponds at Lake Garrett, at Bow Lake and near the end of the Sea-Tac runway will be resized to generate adequate capacity so that the diversion pipeline in some reaches of the drainage sub-basin will not have to be as large as that designed in Alternative Plan I. Streambank protection and flood-plain zoning are identical to that described in Alternative Plan I.

Cost

The estimated cost for this alternative is $8,600,000.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows under existing facilities and also under alternative drainage management solutions for the year 2000. These peak flows are given for the Des Moines Creek and for the remainder of the Lower Puget Sound Sub-Basin.

COMPARISON OF 10-YEAR PEAK FLOWS
(Dubic Feet Per Second)

Location	Existing Facilities	Alternative Plan I	Alternative Plan II
Des Moines Creek			
Upstream from 200 St.	120	70	70
Bow Lake Tributary	150	170	140
South of 200 St.	33	290	230
208 St.	70	430	360
216 St.	340	630	520
Mouth	100	630	530
Remainder			
Salmon Creek Mouth	300	490	300
Salt Water State Park	250	510	510
Woodmont Beach	280	800	800
Creek S.W. of Redondo	124	290	290

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made of the suggested alternative plans for this sub-basin. This process was followed throughout the RIBCO Study in developing alternative plans for the various regional sub-basins. The inspections were based on the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements.

The various structural elements in the alternative plans were checked against the appropriate criteria. The various non-structural elements were reviewed for their relationship to existing and probable future developments. The criteria rating for Alternative Plan I, which uses holding ponds, diversions, streambank protection and some flood-plain zoning, was a negative 2 out of a possible range from a positive total of 108 and a negative total of 108. The total evaluation rating for Alternative Plan II, which employs the same concepts as Alternative Plan I plus land use control on Des Moines Creek, was a positive 4.

Both alternative plans were judged to be effective in controlling drainage. Both plans involved certain trade-offs of human value and human uses of plans once they are built. Environmentally, Alternative Plan II offered some more resource preservation potential than Alternative Plan I which did not involve land use control for the Des Moines Creek area. Neither alternative is part of present planning of any of the involved agencies and therefore, extensive cooperative effort on their parts is required before either plan can be realized. Both of the alternative plans involved extensive commitments of the use and management of natural resources because they rely on certain structural treatments for all or part of their solutions. Therefore, neither alternative can be said to be clearly superior to the other in this concern.

Alternative Plan II relies on flood-plain zoning and land use control from future land development. This combined treatment, if it is to be part of the chosen alternative, should be implemented as an early organized effort. Any portion of the sub-basin that develops without these combined controls will require more structural treatment than Alternative Plan II can accommodate. This issue should be brought to the attention of all citizens and their local agencies. In this case, the flood-plain zoning around Arrow Lake would serve to limit future development.

CONCLUSIONS

In these two alternatives, the combination of parallel pipelines to handle peak water flows that exceed the natural capacity of the preserved natural channel provides a valuable alternative for a predominately developed sub-basin which is located near the metropolitan area of Seattle. The holding ponds provide not only a retention facility for peak flows, but also improves the quality of the water by reducing the amount of silt carried in the runoff waters.

Runoff control, as used in Alternative Plan II, offers advantages in the alleviation of drainage problems. First, they reduce the cost of proposed facilities significantly, by about $100,000. Secondly, the reduced flow rates lessen the damage due to flooding and also improve water quality.

Probably the major disadvantage in both of these two alternatives is that of erosion in the natural streamway. This, unfortunately, is unavoidable unless channels are enlarged to reduce the water velocity or lined with concrete so that high velocities may be maintained without scouring the channels.

King County, the Port of Seattle, the City of Seattle and the City of Normandy Park should establish an effective agreement on a master drainage plan incorporating the conditions of Alternative Plan II. These agencies should then move to implement and enforce the required runoff controls and flood-plain zoning within their own jurisdiction.

RUNOFF QUALITY SUMMARY
LOWER PUGET SOUND

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth of Des Moines Creek	I	630	16	2.1×10^5	.4	1.3	.1
	II	530	19	2.4×10^5	.5	1.5	.1
S. 216 St.	I	630	17	2.1×10^5	.4	1.3	.1
	II	520	19	2.3×10^5	.5	1.6	.2
Bow Lake Tributary	I	170	8	1.0×10^5	.2	.6	.1
	II	140	13	1.5×10^5	.3	.9	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

RUNOFF QUALITY SUMMARY
LOWER PUGET SOUND

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Salmon Creek	I	480	27	1.3×10^6	1.3	2.2	.2
	II	300	12	5.0×10^5	.5	1.0	.1
Stream @ Saltwater Park	I	810	9	1.6×10^5	.2	.6	.1
	II	810	9	1.6×10^5	.2	.6	.1
Stream @ Woodmont	I	510	9	1.7×10^5	.1	.6	.1
	II	510	9	1.7×10^5	.1	.6	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

EVALUATION MATRIX

LOWER PUGET SOUND

ALTERNATIVES	SUB TOTAL	EFFECTIVENESS: Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	SUB TOTAL	HUMAN VALUES: Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	SUB TOTAL	ENVIRONMENTAL FACTORS: High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	SUB TOTAL	IMPLEMENTATION: Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	SUB TOTAL	RESOURCE REQUIREMENTS: Energy	Materials	Land	Capital	RATING TOTAL
CRITERIA WEIGHT		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	+4									+5								+2										-7							-6					-2
II	+4									+5								+6										-7							-4					+4

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Lower Puget Sound, excluding Miller Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
4 Des Moines Creek (DMC)	Channel	13.7'	1,000'	3.5:1 1.5:1	2'	Diversion Pipe	96"	$228,000
5 DMC	Channel	13.7'	200'	3.5:1 1.5:1	3'	Diversion Pipe	84"	$36,000
6 DMC	Culvert	4'	250'	0	6'	Diversion Pipe	60"	$30,000
22 DMC	Channel	8.1'	1,000'	5.1:1 2.9:1	.5'	Diversion Pipe	72"	$149,000
23 DMC	Channel	8.1'	800'	5.1:1 2.9:1	1'	Diversion Pipe	72"	$119,000
43 DMC	Pipe	4'	300'			Diversion Pipe	60"	$36,000
100 DMC	None					Diversion Pipe	72" 1,000'	$149,000
22 DMC	None					Inlet/ Outlet	To 72" parallel diversion pipe	$11,000
23 DMC	None					Inlet/ Outlet	To 72" parallel diversion pipe	$6,000
36 DMC	Pipe	4'	100'				Throttle down existing flow rate capacity	$3,000
43 DMC	None					Inlet/ Outlet	To 60" parallel diversion pipe	$10,000
100 DMC	None					Inlet/ Outlet	To 72" parallel diversion pipe	$6,000
2 DMC	Channel	9.5'	400'	3:1 3:1	2'	Diversion Pipe	84"	$72,000
3 DMC	Box Culvert	18'	110'	0	2'	Diversion Pipe	48"	$10,000
55 DMC	None					Holding Pond	26 AF 11 acres	$125,000
56 DMC	None					Holding Pond	38 AF 20 acres	$1,993,000
2 DMC	None					Inlet/ Outlet	To 84" parallel diversion pipe	$13,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub Basin Lower Puget Sound, excluding Miller Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz. Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
3 DMC	None					Inlet/ Outlet	To 48" parallel diversion pipe	$4,000
4 DMC	None					Inlet/ Outlet	To 96" parallel diversion pipe	$8,000
5 DMC	None					Inlet/ Outlet	To 84" parallel diversion pipe	$7,000
6 DMC	None					Inlet/ Outlet	To 60" parallel diversion pipe	$10,000
87 Lower Puget Sound (LPS)	Channel	2'	2,000'	2:1	2'	Channel	Streambank protection with loose rip-rap	$56,000
89 LPS	Channel	2'	1,000'	2:1	2'	Channel	Streambank protection with loose rip-rap	$28,000
111 LPS	Channel	4'	3,000'	2:1	3'	Channel	Streambank protection with loose rip-rap	$138,000
204 LPS	Channel	2'	2,100'	2:1	2'	Channel	Streambank protection with loose rip-rap	$56,000
112 LPS	Channel	3'	7,000'	2:1	3'	Channel	Streambank protection with loose rip-rap	$303,000
113 LPS	Channel	7'	2,500'	2:1	3'	Channel	Streambank protection with loose rip-rap	$134,000
114 LPS	Channel	4'	2,500'	2:1	2'	Channel	Streambank protection with rip-rap	$83,000
17 LPS	Channel	4'	3,000'	2:1	3'	Channel	Streambank protection with loose rip-rap	$138,000
201 LPS	Channel	3'	5,500'	2:1	3'	Channel	Streambank protection with loose rip-rap	$238,000
18 LPS	Channel	4'	7,000'	2:1	3'	Channel	Streambank protection with loose rip-rap	$46,000
19 LPS	Channel	4'	4,500'	2:1	3'	Channel	Streambank protection with loose rip-rap	$92,000
23 LPS	Channel	3'	3,700'	2:1	3'	Channel	Streambank protection with loose rip-rap	$65,000
202 LPS	Channel	2'	2,000'	2:1	2'	Channel	Streambank protection with loose rip-rap	$28,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Lower Puget Sound excluding Miller Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
203 LPS	Channel	2'	2,000'	2:1	2'	Channel	Streambank protection with loose rip-rap	$28,000
20 LPS	None					Inlet	4 inlets to 24" parallel diversion pipe	$8,000
111 LPS	None					Inlet	3 inlets to 48" parallel diversion pipe	$12,000
112 LPS	None					Inlet	7 inlets to 36" parallel diversion pipe	$20,000
204 LPS	None					Inlet	2 inlets to 36" parallel diversion pipe	$6,000
113 LPS	None					Inlet	3 inlets to 72" parallel diversion pipe	$17,000
114 LPS	None					Inlet	3 inlets to 36" parallel diversion pipe	$9,000
117 LPS	None					Inlet	7 inlets to 48" parallel diversion pipe	$27,000
112 LPS	Channel	3'	7,000'	2:1	3'	Diversion Pipe	36"	$462,000
204 LPS	Channel	2'	2,100'	2:1	2'	Diversion Pipe	36"	$139,000
113 LPS	Channel	7'	2,500'	2:1	2'	Diversion Pipe	72"	$372,000
114 LPS	Channel	4'	2,500'	2:1	2'	Diversion Pipe	36"	$165,000
117 LPS	Channel	3'	6,500'	3:1	3'	Diversion Pipe	48"	$604,000
18 LPS	None					Inlet	7 inlets to 48" parallel diversion pipe	$27,000
19 LPS	None					Inlet	5 inlets to 36" parallel diversion pipe	$14,000
18 LPS	Channel	4'	7,000'	2:1	3'	Diversion Pipe	48"	$651,000
19 LPS	Channel	4'	4,500'	2:1	3'	Diversion Pipe	36"	$297,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub-Basin Lower Puget Sound excluding Miller Creek

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
20 LPS	Channel	3'	3,500'	2:1	3'	Diversion Pipe	24"	$147,000
205 LPS	Pipe	30"	40'			Parallel Pipe	24"	$2,000
88 LPS	Pipe	21"	30'			Parallel Pipe	24"	$1,000
93 LPS	Pipe	24"	30'			Parallel Pipe	24"	$1,000
111 LPS	Channel	4'	3,000'	2:1	3'	Diversion Pipe	48"	$279,000
117 LPS	Channel	3'	6,500'	3:1	3'	Channel	Streambank protection with loose rip-rap	$351,000
118 LPS	Channel	3'	2,500'	2:1	3'	Channel	Streambank protection with loose rip-rap	$87,000
123 LPS	Channel	3'	6,000'	2:1	3'	Channel	Streambank protection with loose rip-rap	$259,000
124 LPS	Channel	3'	6,000'	2:1	3'	Channel	Streambank protection with loose rip-rap	$259,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $8,674,000

Round To: $8,700,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Lower Puget Sound, excluding Miller Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
100 DMC	None	None for	proposed	facility		Inlet/ Outlet	To 72" parallel diversion pipe	$6,000
2 DMC	Channel	9.5'	400'	.3:1 3:1	2'	Diversion Pipe	84"	$72,000
4 DMC	Channel	13.7'	1,100'	3.5:1 1.5:1	2'	Diversion Pipe	96"	$228,000
5 DMC	Channel	13.7'	200'	3.5:1 1.5:1	3'	Diversion Pipe	84"	$36,000
6 DMC	Box Culvert	4'	250'	0:0	6'	Diversion Pipe	60"	$30,000
22 DMC	Channel	8.1'	1,000'	5.1:1 2.9:1	.5'	Diversion Pipe	72"	$149,000
23 DMC	Channel	8.1'	800'	5.1:1 2.9:1	1'	Diversion Pipe	72"	$119,000
4 DMC	None					Inlet/ Outlet	To 96" parallel diversion pipe	$8,000
5 DMC	None					Inlet/ Outlet	To 84" parallel diversion pipe	$7,000
6 DMC	None					Inlet/ Outlet	To 60" parallel diversion pipe	$10,000
22 DMC	None					Inlet/ Outlet	To 72" parallel diversion pipe	$11,000
23 DMC	None					Inlet/ Outlet	To 72" parallel diversion pipe	$6,000
36 DMC	Pipe	4'	100'				Throttle down existing flow rate capacity	$3,000
43 DMC	None					Inlet/ Outlet	To 60" parallel diversion pipe	$10,000
113 LPS	None					Inlet	3 inlets to 72" parallel diversion pipe	$17,000
114 LPS	None					Inlet	3 inlets to 36" parallel diversion pipe	$9,000
117 LPS	None					Inlet	7 inlets to 48" parallel diversion pipe	$27,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Lower Puget Sound, excluding Miller Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
21 LPS	None					Holding Pond	2AF 6 acres	$375,000
55 DMC	None					Holding Pond	21 AF 11 acres	$117,000
56 DMC	None					Holding Pond	27 AF 20 acres	$1,982,000
2 DMC	None					Inlet/ Outlet	To 84" parallel diversion pipe	$13,000
23 LPS	Channel	3'	3,700'	2:1	3'	Channel	Streambank protection with loose rip-rap	$65,000
202 LPS	Channel	2'	2,000'	2:1	2'	Channel	Streambank protection with loose rip-rap	$28,000
203 LPS	Channel	2'	2,000'	2:1	2'	Channel	Streambank protection with loose rip-rap	$28,000
87 LPS	Channel	2'	2,000'	2:1	2'	Channel	Streambank protection with loose rip-rap	$56,000
89 LPS	Channel	2'	1,000'	2:1	2'	Channel	Streambank protection with loose rip-rap	$28,000
111 LPS	Channel	4'	3,000'	2:1	3'	Channel	Streambank protection with loose rip-rap	$138,000
204 LPS	Channel	2'	2,100'	2:1	2'	Channel	Streambank protection with loose rip-rap	$56,000
43 DMC	Pipe	4'	300'			Diversion Pipe	60'	$36,000
100 DMC	None					Diversion Pipe	72" 1,000'	$149,000
206 LPS	None					Pipe	18" 100'	$3,000
17 LPS	Channel	4'	3,000'	2:1	3'	Channel	Streambank protection with loose rip-rap	$138,000
201 LPS	Channel	3'	5,500'	2:1	3'	Channel	Streambank protection with loose rip-rap	$238,000
18 LPS	Channel	4'	7,000'	2:1	3'	Channel	Streambank protection with loose rip-rap	$46,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Lower Puget Sound, excluding Miller Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
19 LPS	Channel	4'	4,500'	2:1	3'	Channel	Streambank protection with loose rip-rap	$92,000
18 LPS	Channel	4'	7,000'	2:1	3'	Diversion Pipe	48"	$651,000
205 LPS	Pipe	30"	40'			Parallel Pipe	24"	$2,000
88 LPS	Pipe	21"	30'			Parallel Pipe	24"	$1,000
93 LPS	Pipe	24"	30'			Parallel Pipe	24"	$1,000
111 LPS	Channel	4'	3,000'	2:1	3'	Diversion Pipe	48"	$279,000
112 LPS	Channel	3'	7,000'	2:1	3'	Diversion Pipe	36"	$462,000
204 LPS	Channel	2'	2,100'	2:1	2'	Diversion Pipe	36"	$139,000
113 LPS	Channel	7'	2,500'	2:1	2'	Diversion Pipe	72"	$373,000
114 LPS	Channel	4'	2,500'	2:1	2'	Diversion Pipe	36"	$165,000
117 LPS	Channel	3'	6,500'	3:1	3'	Diversion Pipe	48"	$605,000
18 LPS	None					Inlet	7 inlets to 48" parallel diversion pipe	$27,000
111 LPS	None					Inlet	3 inlets to 48" parallel diversion pipe	$11,000
112 LPS	None					Inlet	7 inlets to 36" parallel diversion pipe	$20,000
204 LPS	None					Inlet	2 inlets to 36" parallel diversion pipe	$6,000
112 LPS	Channel	3'	7,000'	2:1	3'	Channel	Streambank protection with loose rip-rap	$303,000
113 LPS	Channel	7'	2,500'	2:1	3'	Channel	Streambank protection with loose rip-rap	$134,000

The estimated cost for this alternative is $8,600,000.

P-3-6

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

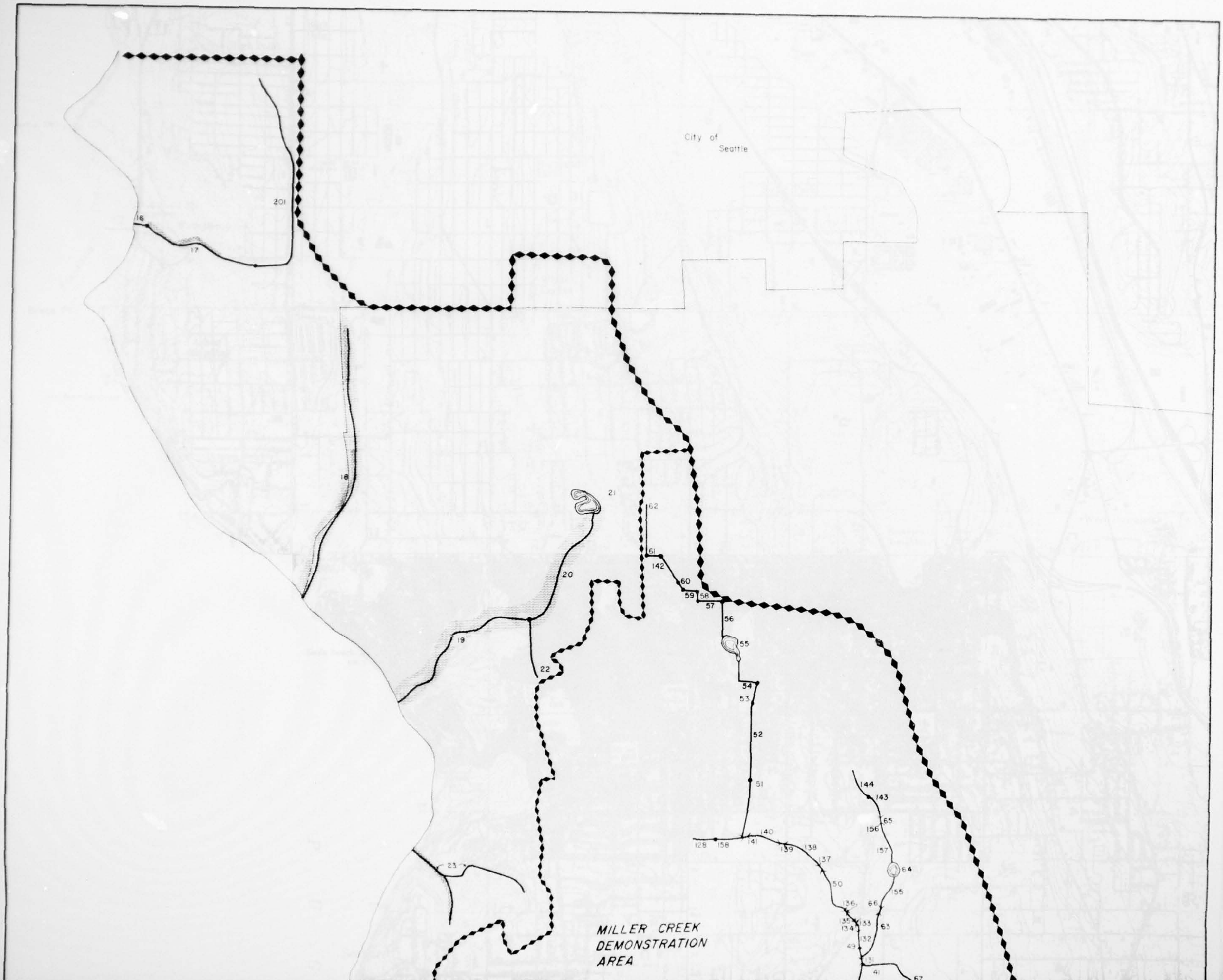
Alternative II Sub Basin Lower Puget Sound, excluding Miller Creek

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
114 LPS	Channel	4'	2,500'	2:1	2'	Channel	Streambank protection with rip-rap	$83,000
117 LPS	Channel	3'	6,500'	3:1	3'	Channel	Streambank protection with loose rip-rap	$351,100
118 LPS	Channel	3'	2,500'	2:1	3'	Channel	Streambank protection with loose rip-rap	$87,000
123 LPS	Channel	3'	6,000'	2:1	3'	Channel	Streambank protection with loose rip-rap	$259,000
124 LPS	Channel	3'	6,000'	2:1	3'	Channel	Streambank protection with loose rip-rap	$259,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $8,554,000

Round To: $8,600,000



City of Seattle
MILLER CREEK DEMONSTRATION AREA
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AD-A042 167 KCM-WRE/YTO SEATTLE WASH F/G 8/8
ENVIRONMENTAL PLANNING FOR THE METROPOLITAN AREA CEDAR-GREEN RI--ETC(U)
DEC 74 DACW67-73-C-0022

UNCLASSIFIED NL

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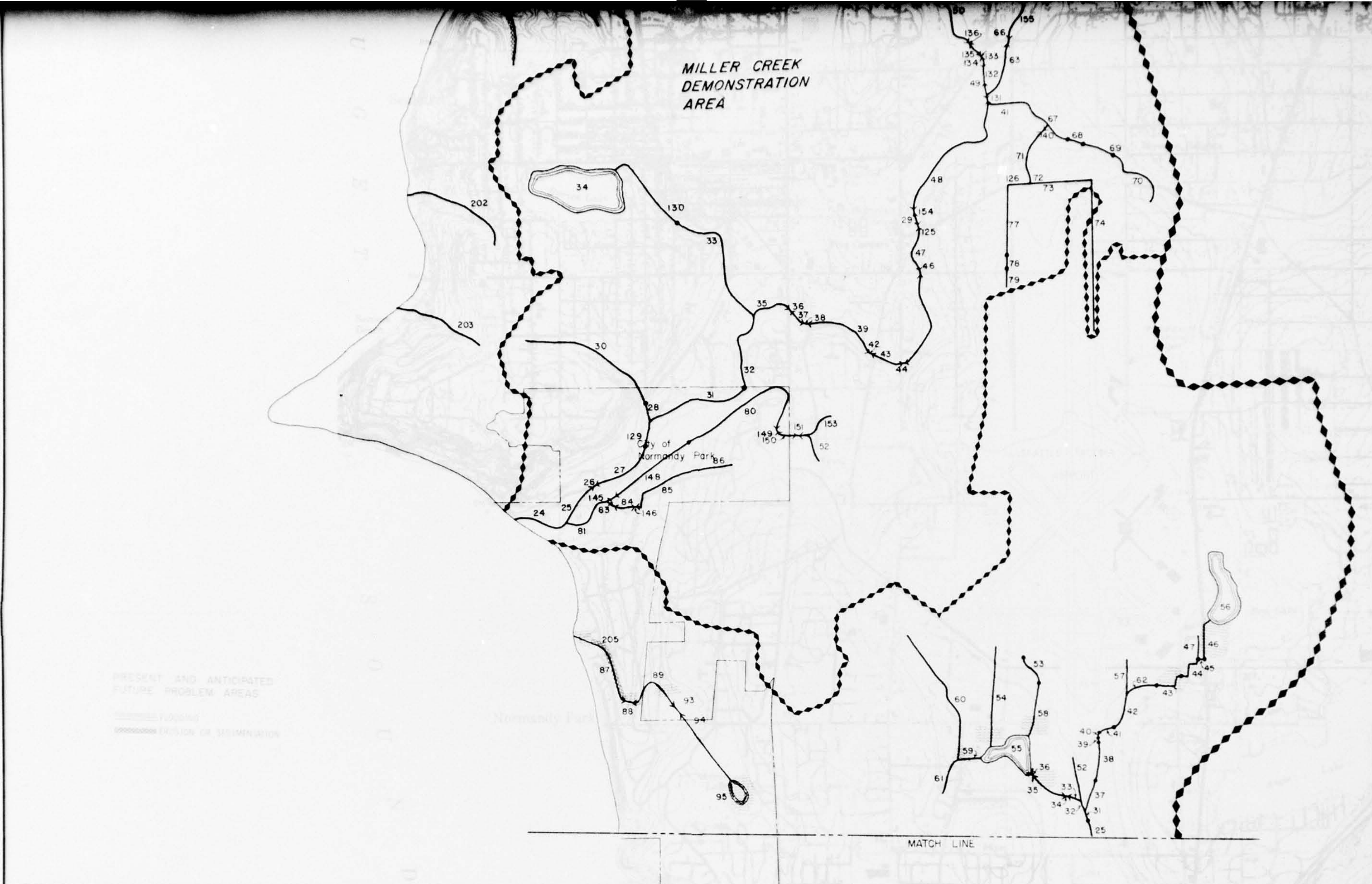


LEGEND

- SUB-BASIN BOUNDARY
- EXISTING CHANNEL
- EXISTING CONDUIT
- MANHOLE, INLET, OR JUNCTION
- CHANNEL OR CONDUIT DESIG. C-5-4
- CITY LIMITS
- COUNTY (METRO) BOUNDARY
- LEVEE
- CULVERT
- HOLDING POND OR LAKE

MILES: 1/2, 1/4, 0, 1

FEET: 1000, 500, 0, 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER PUGET SOUND

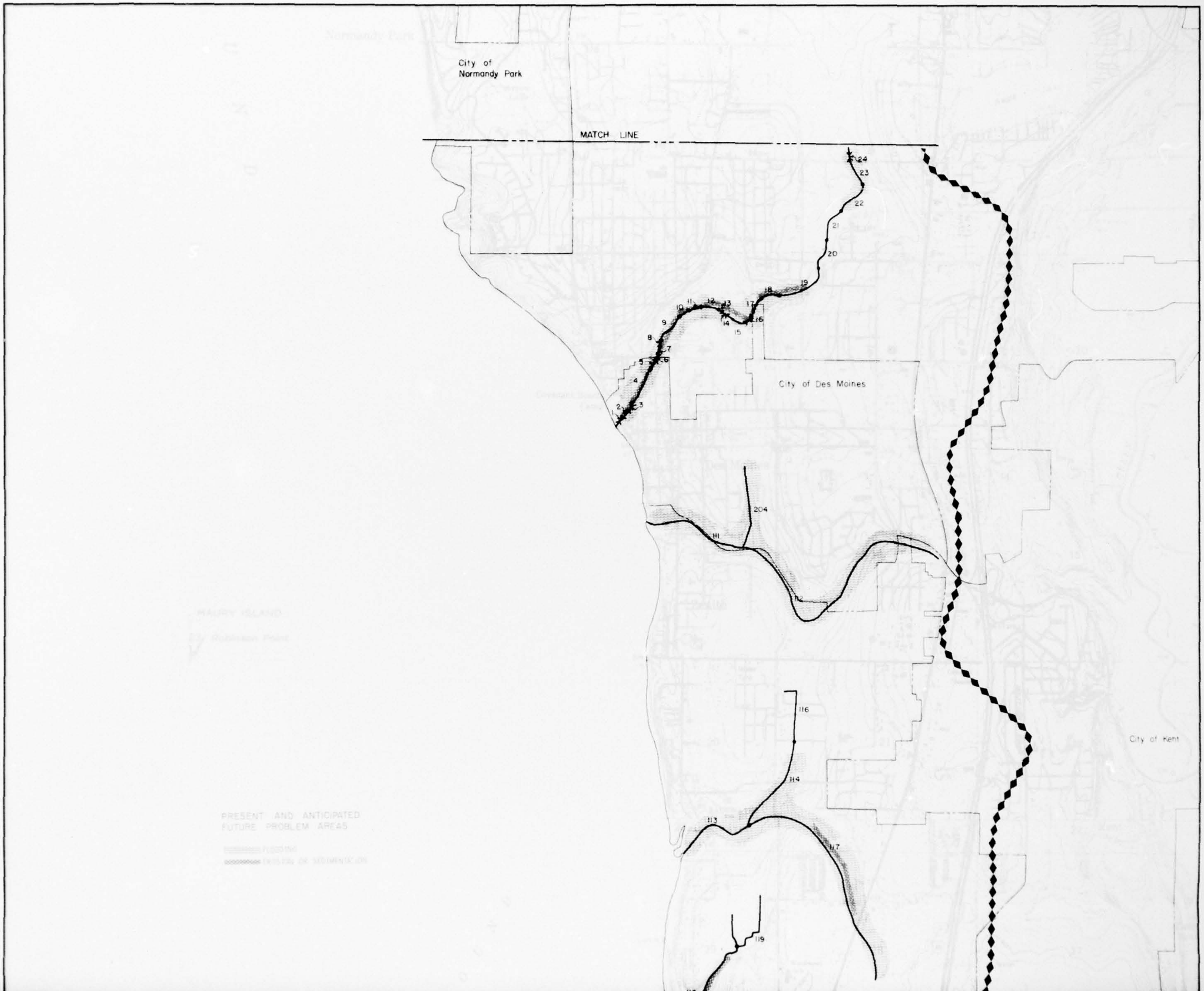
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1 OF 2

2


City of Normandy Park
MATCH LINE
City of Des Moines
City of Kent
MAURY ISLAND
Robinson Point
PRESENT AND ANTICIPATED FUTURE PROBLEM AREAS
FLOODING
EROSION OR SEDIMENTATION
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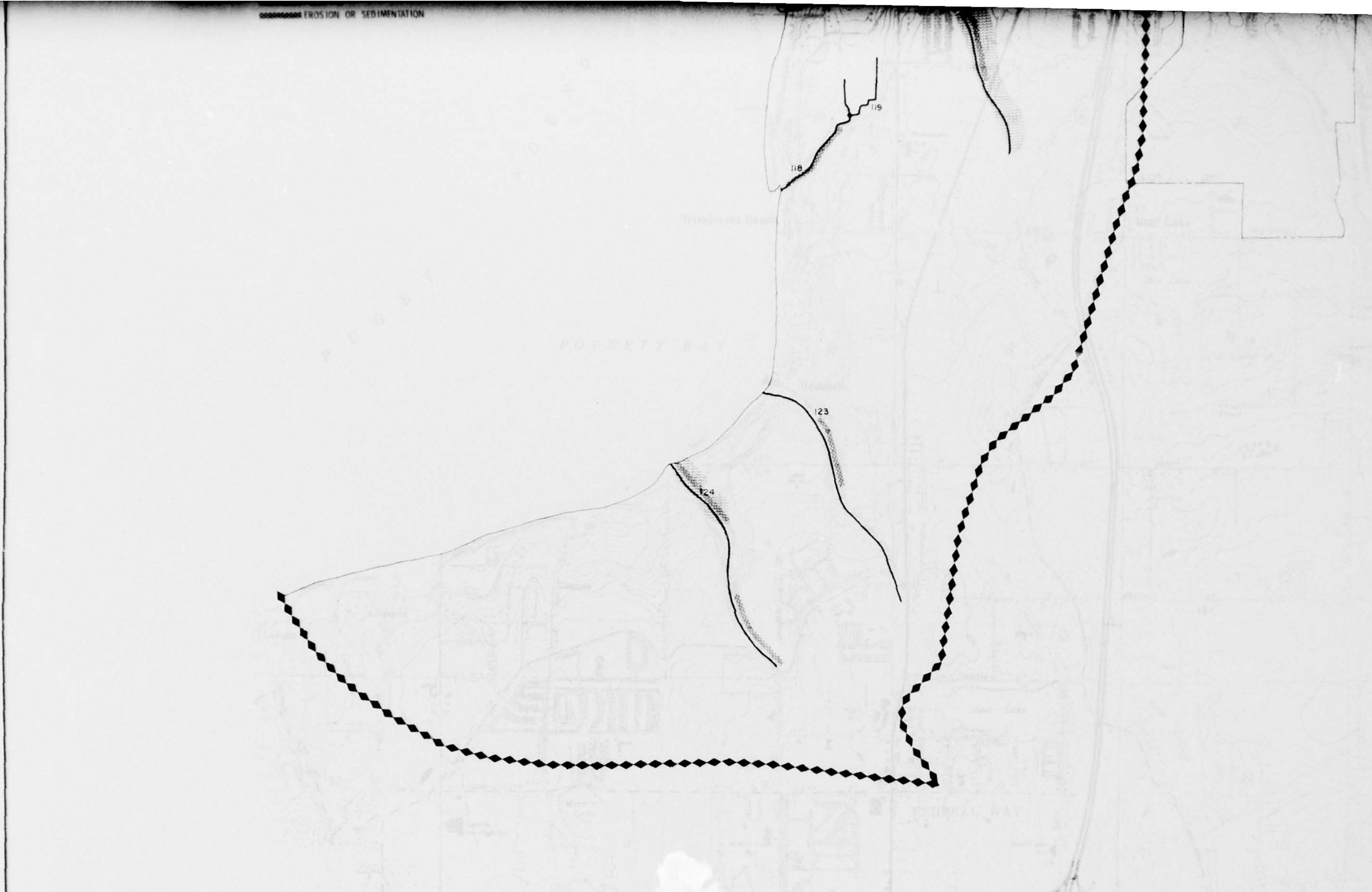


LEGEND

SUB BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

N

MILES 1/2 1/4 0

FEET 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER PUGET SOUND

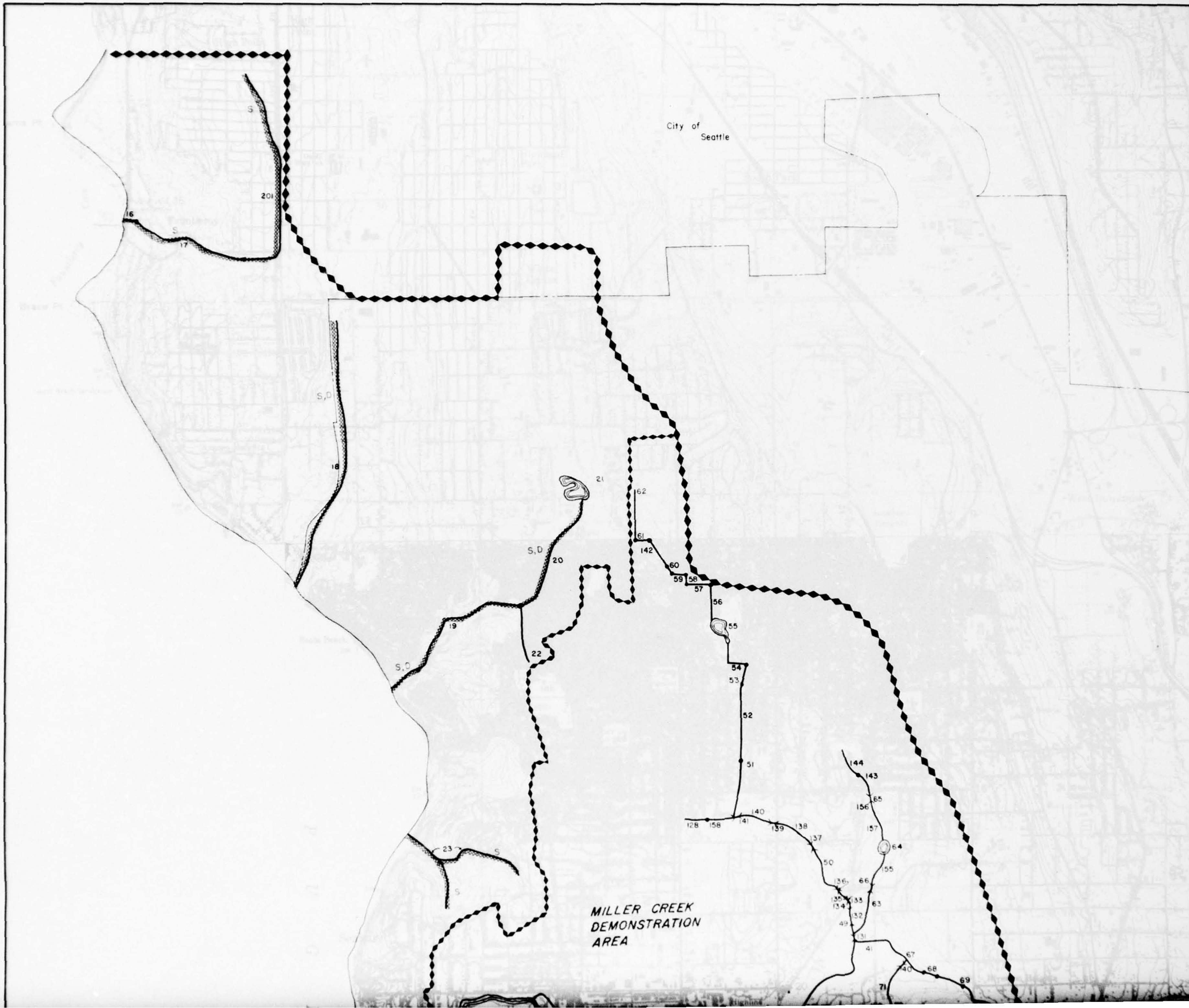
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 2 OF 2

2


City of Seattle
MILLER CREEK DEMONSTRATION AREA
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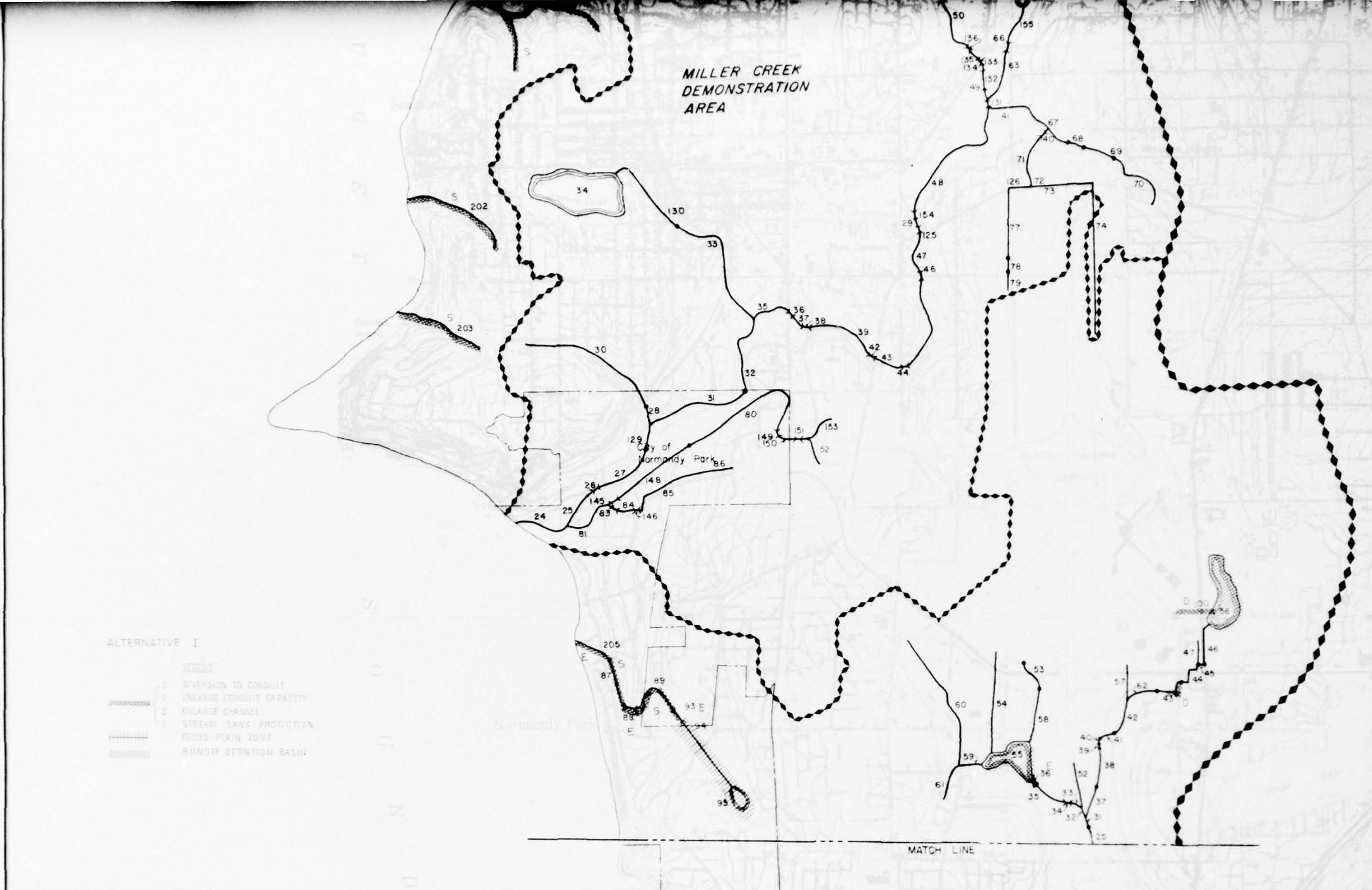

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. C-5-4
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

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MILES 1/2 1/4 0 1

FEET 1000 500 0 4000

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER PUGET SOUND

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 10 OF 2

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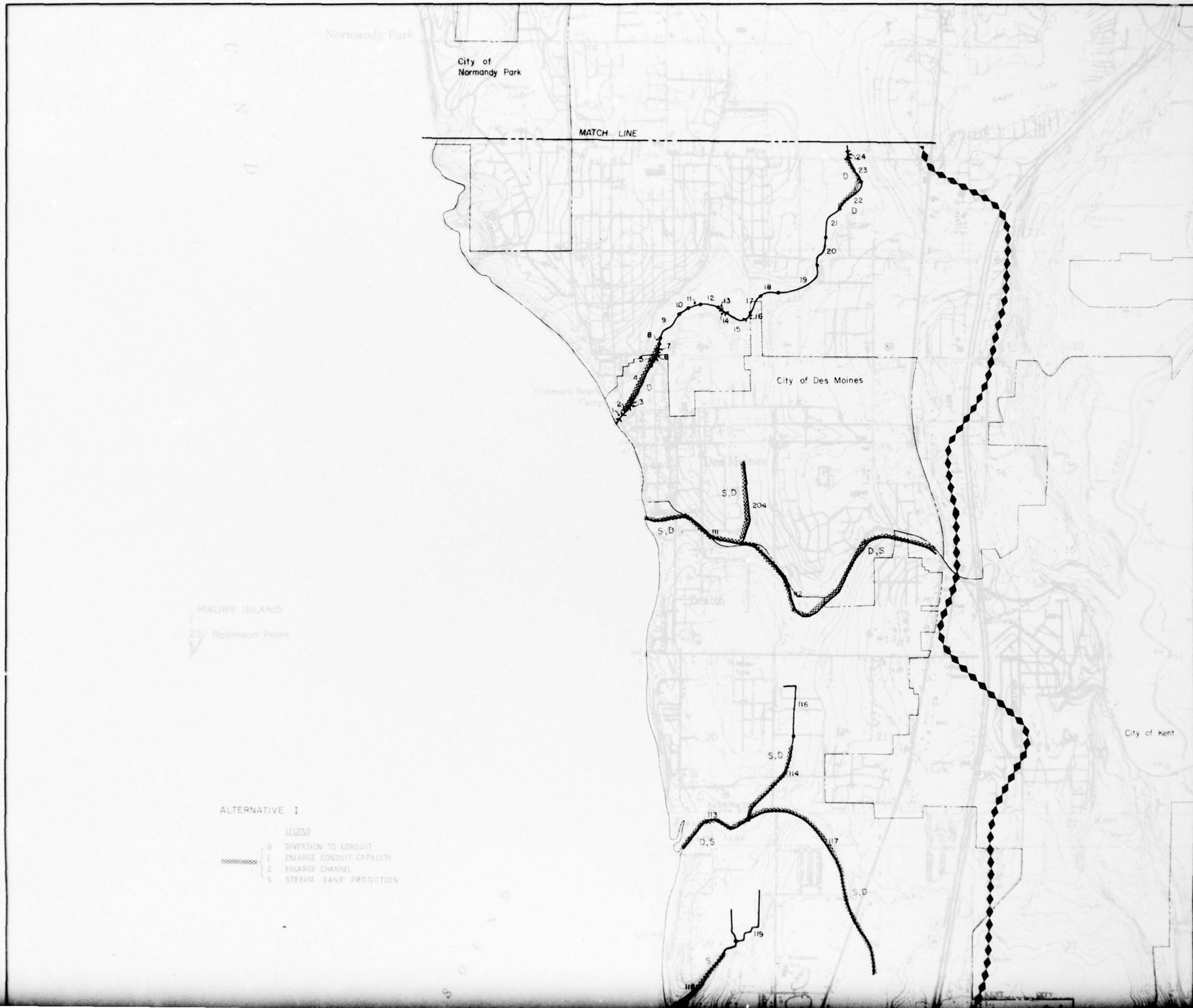

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MATCH LINE
City of Des Moines
City of Kent
MAURY ISLAND
Robinson Point
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C ENLARGE CHANNEL
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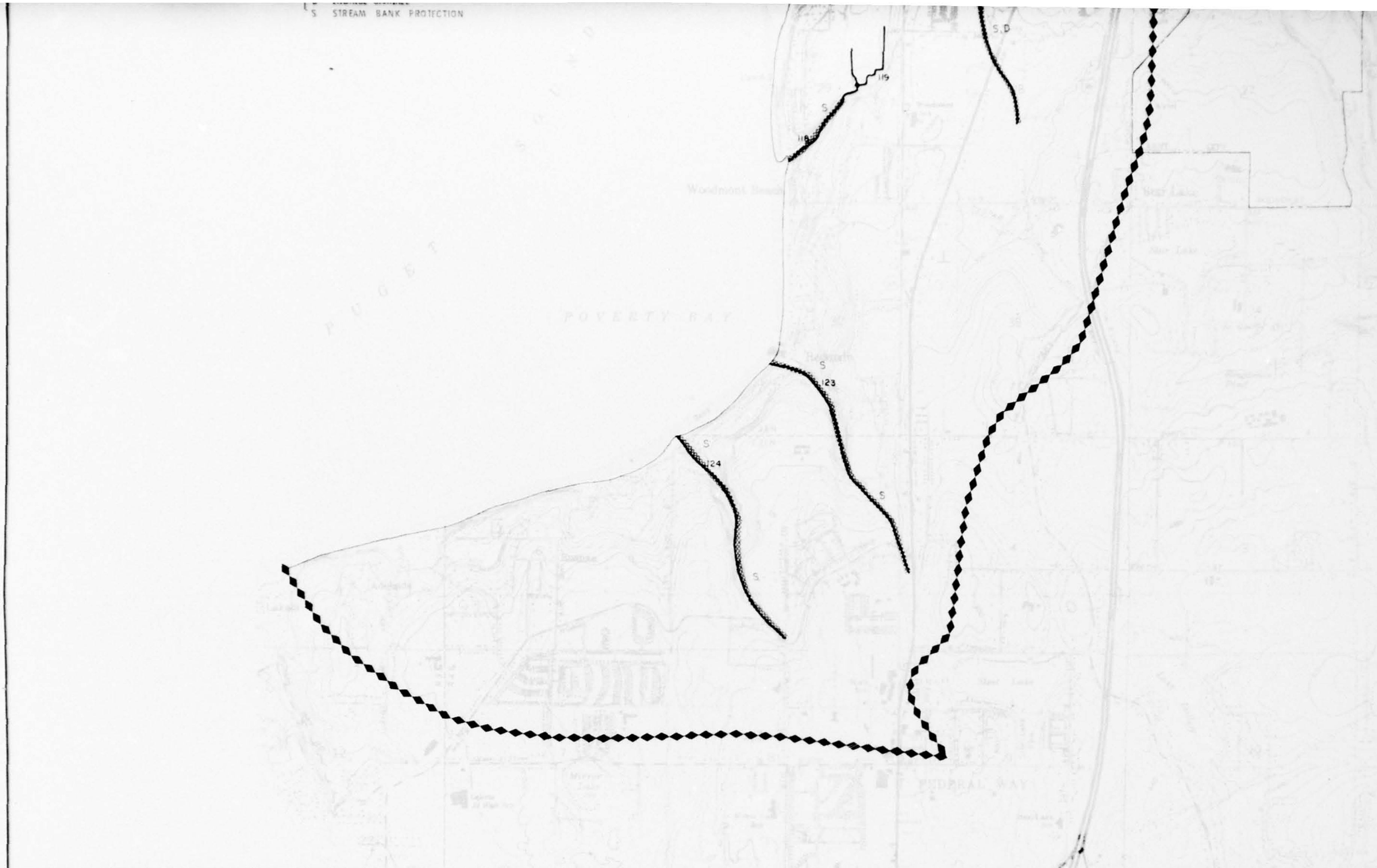

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CULVERT	
HOLDING POND OR LAKE	

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MILES: 1/2, 1/4, 0, 1

FEET: 1000, 500, 0, 4000

NO	DESCRIPTION	DATE	APPROVED

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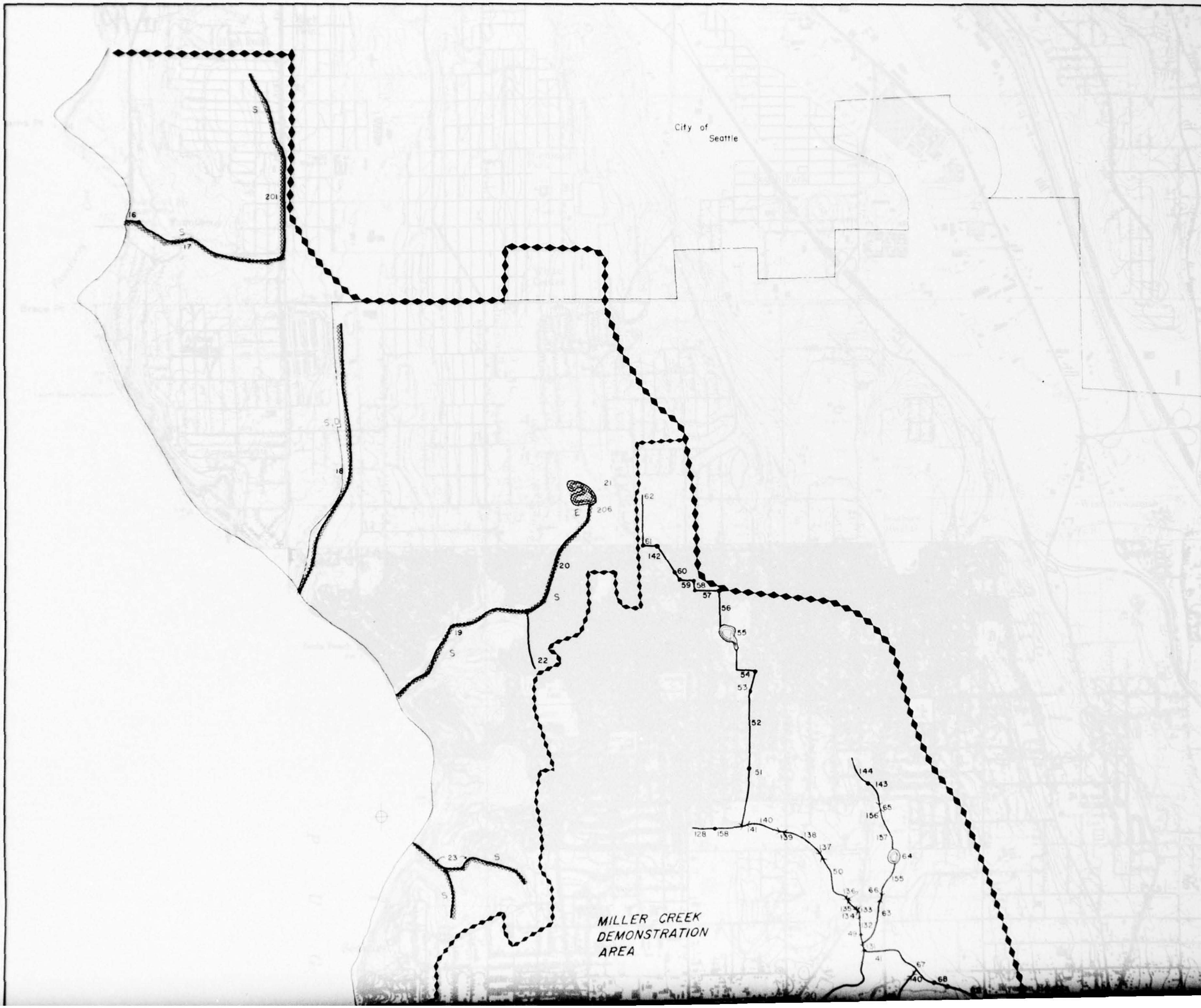
City of Seattle
MILLER CREEK DEMONSTRATION AREA
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Normandy Park
City of Normandy Park
MATCH LINE
City of Des Moines
City of Kent
HAURY ISLAND
Robinson Point
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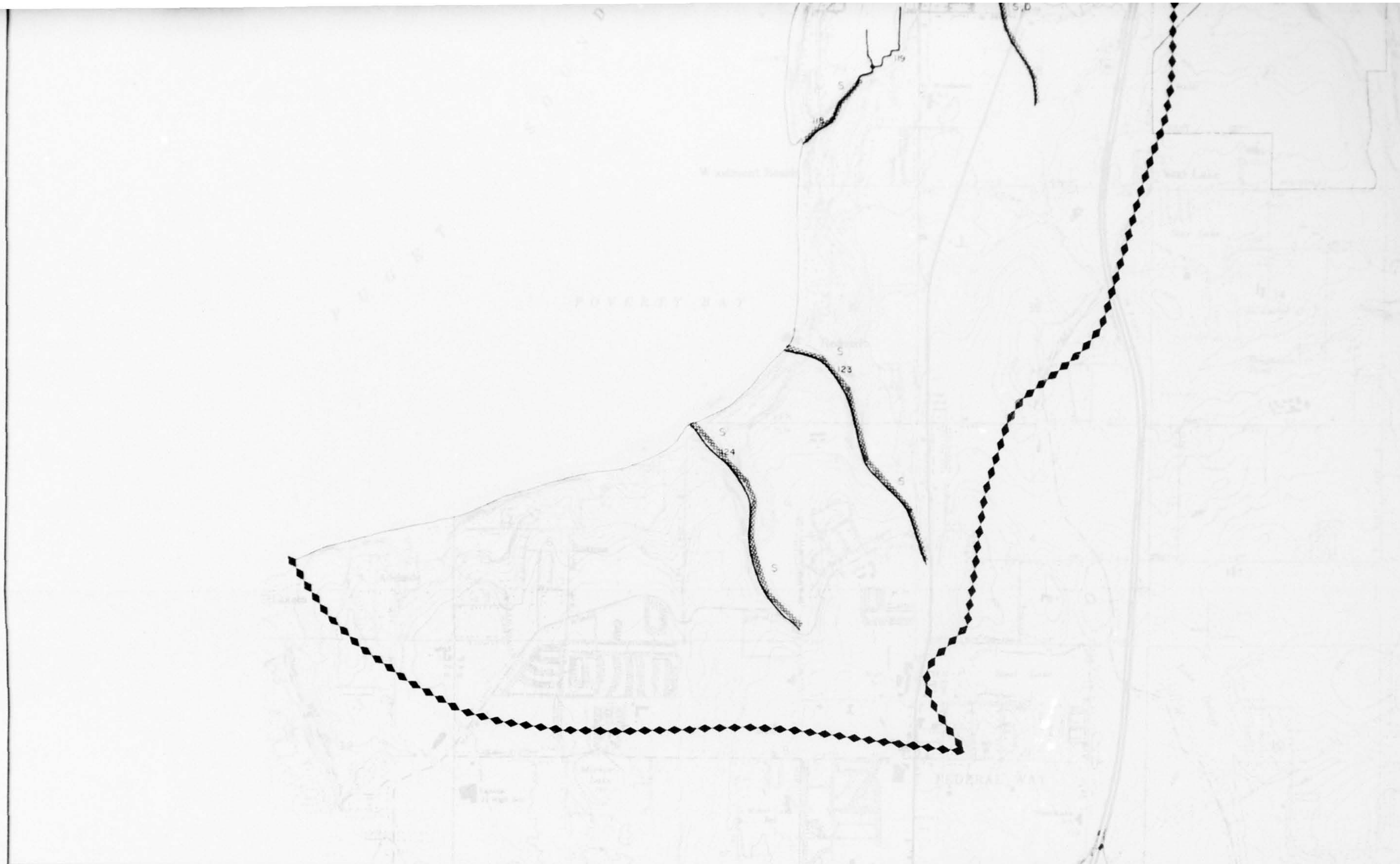

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
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MANHOLE, INLET, OR JUNCTION
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REGIONAL SUB-BASIN G-5

MILL CREEK DEMONSTRATION AREA

GENERAL DESCRIPTION

The Mill Creek sub-area drains the western third of the Lower Green River Sub-Basin and is located between Kent and Auburn. The Lower Green River Sub-Basin has been evaluated separately from this demonstration area.

The Mill Creek valley is a broad flat flood plain with steep hills and uplands bordering its west side and the Green River sub-basin on the east side. Terraces, lakes and marshy depressions characterize the uplands. The valley is composed of fertile alleuvial soils that have been deposited by the Green River and Mill Creek. Both agricultural and urban/industrial development have taken place in the valley.

Mill Creek discharges to Green River near Kent, and extends up through Peasley Canyon to originate at Lake Dolloff.

Stream	Category	Drainage Area	Discharge
Mill Creek	II	13 sq. mi.	Green River

Approximately 40 percent of the sub-area is utilized for commercial farming, principally dairy. Substantial industrialization, freeway development and railway facilities exist in the valley. A large percentage of the residential use is rural low-density development. These and other land uses are shown as percentages of total land area in the following table.

PERCENT OF SUB-AREA IN SPECIFIED LAND USE

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	40	50	50
Multiple Family			
Commercial/Services	5	10	10
Govt. and Educ.			
Industrial	10	30	30
Parks/Dedicated Open Space	5	5	5
Agriculture	20		
Airports, Railyards, Freeways, Highways	5	5	5

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Unused Land	15		
Water			
Total	100	100	100
Total Impervious Area	20	55	55

The year 2000 Comprehensive and year 2000 Corridor are exactly the same. Future land-use projections indicate that industry and commerce will occupy nearly all of the valley, and that suburban residential development will increase in the uplands and around Auburn. Commercial farming, in all likelihood will be limited to very intensive greenhouse culture and possibly some dairy industry. Future land use plans for intensive industrial development of the Mill Creek sub-area have been subjected to much public and official criticism but are now accepted projections by regional planning agencies.

NATURE OF EXISTING DRAINAGE SYSTEM

The Mill Creek sub-area drainage system consists of a pastoral section within the greater Green River flood plain and an upland system of streams and lakes serving the area immediately west of the Green River flood plain at Auburn. The portion of Mill Creek within the flood plain contains both natural channels as well as portions of man-made channelization and diversion. The Peasley Canyon stretch of Mill Creek has been lined in several places to prevent channel erosion. Several smaller upland tributaries also have been realigned and channelized through problem areas. Small natural wetland storage areas exist in the upper sub-area as do two major lakes, both being at the headwaters of the major tributaries of Mill Creek.

Mill Creek has recognized spawning areas for coho salmon and various other game fish.

DRAINAGE PROBLEMS

Flooding in the Mill Creek Valley continues to be the most prominent annual problem. The lower reach of Mill Creek and adjacent lands are subject to backwater from high stages in the Green River. The combination of high river stages, and rainfall from within the sub-area compounds the flooding problem and causes ponding of other poorly drained areas. The general extent of flooding from these two causes is indicated on the attached problem map. As a consequence of flooding and poor internal drainage, the flat valley also sustains a very high water table throughout the winter season.

Ponding has been noted in several rural locations which are not a consequence of the general flood problems along Mill Creek but rather due to inadequate drainage facilities and flat slopes. Also, several areas in Auburn such as along Auburn Way North, along Main Street and open areas north of 15th St. N.W. are commonly ponded. Ponding also has been experienced

in the uplands. Immediately below Lake Geneva, the stream gradient is flat and this reach receives runoff from the adjacent hillside development. Downstream culvert capacity and stream gradients are inadequate for prevention of ponding.

Erosion problems are prevalent on the steeper slopes and channel reaches, and without runoff control, more erosion can be expected. Several reaches of Mill Creek within Peasley Canyon have been lined to prevent channel erosion. The steep hillside, which runs through the drainage sub-area has a high slippage potential.

The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Land-Use Plans. Therefore, the drainage alternatives presented herein are applicable to both plans. The table of projected land uses indicates that total impervious area within the Mill Creek sub-area will increase from an existing level of 20% to approximately 55% by the year 2000.

Under future land-use conditions, problems will be substantially increased. Nearly all the channels north of SR-18 would be inadequate. Several storm drains along Auburn Way North would surcharge. Capacities of several culverts in Peasley Canyon would be exceeded.

Reported property damages obtained from local agencies placed the average annual loss for the Mill Creek sub-area at $44,100.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

Several drainage alternatives have been suggested for alleviation of the area's drainage problems. In November the public suggested the following alternatives for investigation.

1. Divert Mill Creek to the White River.

2. Construct a flood gate on the mouth of Mill Creek and pump into the Green River.

3. Divert Mill Creek adjacent to the freeway (SR-167) and enlarge the creek.

Other drainage solutions considered, some of which were included in the alternatives evaluated, were as follows:

1. Continuation of present trends including channel realignment dredging, and similar works;

2. Storm water diversion facilities to transport runoff directly to the Green River;

3. Flood plain management with building constraints and flood proofing;

4. Channelization and streambank protection; and

5. Watershed management to provide on-site storage for runoff, especially in the uplands.

The West Side Green-Duwamish Watershed Work Plan, under Public Law No. 566, has been adopted as the comprehensive drainage plan by its sponsoring agencies. Funds for construction have been authorized by Congress but construction cannot begin until the Environmental Impact Statement has been approved. The City of Auburn is committed to support the PL-566 plan and would benefit from construction of two major systems which lie within the Mill Creek sub-area. Other sponsors of the watershed plan are the cities of Kent, Renton, and Tukwila, King County, the Green River Flood Control Zone District, and the King County Soil and Water Conservation District. The Environmental Impact Statement is scheduled to be completed in 1974 and construction could begin in 1975. The City of Auburn, meanwhile, is conducting a storm drainage study together with a storm separation study.

Engineering staff members from Auburn and King County were consulted during the preparation of the alternative plans presented herein.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Mill Creek sub-area as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions were provided in development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concept

Channelization and construction of a pump station at the mouth of Mill Creek would eliminate flooding in the valley. All laterals and storm drains would be enlarged where necessary to accommodate the peak flow from the 10-year storm with negligible surcharge in the systems. Upland storage in Lake Dolloff and Lake Geneva would control flows into downstream channels.

Major Features

Pump Station: A major pump facility with fully automatic controls, glood gates, and fish passage would be constructed on the mouth of Mill Creek. The pump would be designed to discharge to the Green River at flood stage.

Channelization: The main reach of Mill Creek would be widened and cleared. Some reaches would be deepened to grade as defined by invert elevations on bridges and culverts on the main reach. Also several bridges and culverts would need to be enlarged to accommodate peak flows. Embankments of the main channel would be gravel lined in reaches where grass lining is inadequate.

Urban Systems: Open channel systems within the urban-industrial zone in the valley would be enlarged and lined with concrete. Flat slopes preclude utilization of buried storm drains in many of the existing open channel reaches. Existing storm drains would be supplemented with parallel lines where necessary.

Upland Channels: Streambank protection will be required because of extremely steep stream gradients. Existing lined reaches of Peasley Canyon would be preserved. The lower reach in Peasley Canyon would be provided with concrete energy dissipators to reduce velocities where the creek enters the flood plain.

Cost

The cost for Alternative Plan I is estimated to be $6,400,000.

ALTERNATIVE PLAN II

General Concept

The floodway drainage plan would preserve the existing stream channel and utilize set-back levees to protect the adjacent land from the Green River backwater. The natural vegetation along the main stream would be preserved, and the channel bed would be unchanged to maintain fish and wildlife habitats. Pumped drainage canals and storm drains would alleviate local flood problems and lower the water table. Detention ponds would be incorporated into the uplands drainage system to reduce peak flows to upland channels. A major feature of this plan is that all upland drainage from Peasley Canyon, Algona and areas west of Main Street would be routed into the floodway thus eliminating the necessity of pumping these flows into the river. Drainage system improvements in Auburn and Algona are the same as for Alternative Plan I.

Major Features

Floodway: Earth levees join the existing Green River levee system and follow Mill Creek on grade to protect adjacent lands from periodic backwater flooding from Green River. Some culverts and bridges would need to be enlarged to prevent excessive flow-through velocities. The levees would have 20-foot top widths with gentle side slopes. These could be planted with trees and natural vegetation while the berm would be maintained as an open grassed surface.

Lateral Drains and Pump Stations: Existing lateral drainage canals would be intercepted by pumped drainage canals that parallel the toe of the levees. A total of eight pump stations with a combined peak flow rate of 790 cfs are necessary to provide storm-drainage peaking capacity. The pumps also could be utilized to lower groundwater tables in the non-flooding season. An advantage of this alternate is that any individual pump station could be constructed independently of the others whenever it is deemed that the additional protection is necessary. Until that time, a simple flood gate would provide as much protection in the flood plains as in the existing system.

Urban Systems: The systems in Auburn and Algona are the same as proposed in Alternative Plan I. Grassed channels could be utilized, however, instead of asphalt-lined channels in the industrial sector. Runoff control in the uplands would be provided by four detention ponds with a range from 5 to 20 acre feet of capacity. Outflow during the 10-year storm is reduced to downstream channels. Specifically, the proposed detention ponds are as follows:

		Storage Capacity Acre Feet
1.	Mill Creek at 322nd crossing	20
2.	Unnamed stream above 51st Ave. So.	4
3.	Unnamed stream above Mt. View Cemetery	4
4.	Stream below Lake Geneva	5

Minor improvements are made to channels and facilities to accommodate direct hillside drainage.

Cost

The cost for Alternative Plan II is estimated to be $6,700,000.

ALTERNATIVE PLAN III - PL-566 WATERSHED PROJECT

General Concept

The West Green River Watershed Work Plans were prepared by the Soil Conservation Service in 1960 and were authorized for construction by Congress in 1966. None of the project has been built in the Mill Creek sub-area, however. The general plan and grade lines have been adopted for location of culverts in highway construction and storm-drainage outlets. The plan incorporates pump stations and extensive channelization which would provide storm drainage and flood protection to the valley. Alternative Plan III reflects approximate alignment of the channels, and the final plan has not yet been completed by SCS.

Major Features

Pump Stations: The P-4 pump station, having a capacity of 1250 cfs, will be located on Mullen Slough. The P-4 channel will intercept Mill Creek and divert flows during flood stages to the pump station. A flood gate will be provided at the mouth of the existing Mill Creek to prevent waters in the Green River from flowing into Mill Creek. The P-7 pump station will discharge a peak flow of 225 cfs at a point near the Auburn Way North bridge across the Green River.

Channels: The P-4 channel will follow the alignment of SR-167 on the west side of Algona, and will intercept flows from Mill Creek at Peasley Canyon. The P-4A channel will follow the east side of SR-167

and intercept existing drainage canals. The channel also drains a substantial area outside the Mill Creek watershed. The P-11 and P-7 channels would conform to the existing creek alignment.

Cost

The cost for Alternative Plan III is estimated to be $5,800,000. based on 1964 cost estimates for the SCS channelization project. This estimate does not include land acquisition cost.

PEAK FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and land use, for the three alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

	Existing Land Use				
Location	Existing Facilities	Existing Facilities	Alternative Plan I	Alternative Plan II	Alternative Plan III
At Green River	200*	300*	1400	1000	1340
37th Street N.W.	180*	260*	1370	850	1000
Algona Channel	50	140	270	270	-
At Peasley Canyon	170*	290*	420	290	420
Auburn Way North Storm Drain	50*	50*	170	170	310

*Surcharge occurred upstream and actual discharge would be greater.

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternative plans for this sub-area. This procedure was followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins and demonstration areas. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural solutions were checked against the appropriate criteria and the various non-structural solutions were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs check dams, streambank protection, construction of new channels and pump stations, was a minus 47, on a scale ranging from positive 108 to negative 108. The total evaluation rating for Alternative Plan II, which employs enlarged channels, storage, and flood-plain zoning, was a plus 10. The total

evaluation rating for Alternative Plan III, which employs drop structures, streambank protection, construction of new channels, and pumping, was a minus 30.

Alternative Plan II received a positive rating for effectiveness, whereas both Alternative Plans I and III received negative totals in this category. All three alternative plans were judged to provide adequate flood damage reduction, but only Alternative Plan II provided erosion and sedimentation control as well as protection from overcharge of the system. Alternative Plan II also received a positive rating for promotion of human values, in contrast to Alternative Plans I and III which received negative ratings in this category. The positive score for Alternative Plan II was attributed to the multiple use potential of the main channel for flood-plain zoning and the potential for community cohesion offered by the preservation of open space adjacent to the main channel of Mill Creek. Alternative Plan II received a positive rating for environmental factors, with both Alternative Plans I and III receiving low negative scores in this category. Alternative Plan II should have positive effects upon aquatic life and vegetation as well as assuring low-flow conditions. Alternative Plans I and III were not able to positively effect any environmental factors.

Alternative Plan III, the Soil Conservation Service Plan, was the only alternative receiving a positive rating for implementation. This is based upon the fact that this SCS plan is approved and has funding and requires now only the filing of an environmental impact statement prior to construction. Both Alternative Plans I and II require jurisdictional coordination and financing. All three alternative plans are judged to be relatively consumptive of resources and all received negative ratings in this category. Alternative Plan II which has multiple use potential had the best rating.

Alternative Plan II has two critical elements associated with it. They are: 1) use of flood-plain zoning and 2) the designation of storage sites within the upper sub-area. This treatment combination, if it is to be part of the chosen alternative, should be implemented as an early organized effort of the involved agencies. Loss of the storage areas and encroachment upon the flood-plain zone would force the use of a more structural treatment than Alternative Plan II can accommodate. This issue should be brought to the attention of all citizens and their local agencies. Alternative Plan III, although it does have funding and authorization, involves sacrifices in terms of the natural environment. Much of the land which was to be protected by this system, is no longer destined for agricultural use.

CONCLUSIONS

Alternative Plan II is clearly superior to either Alternative Plan I or Alternative Plan III because of the potential for use of existing storage areas and the ability to contain Mill Creek in a floodway that preserves the natural stream course. Alternative Plan II would require immediate action, however, to protect and preserve these natural amenities. This action would require coordination of both Auburn and King County in the Mill Creek sub-area.

King County and the City of Auburn should establish an effective agreement for a master drainage plan, that incorporates the provisions of Alternative Plan II. These agencies then should move to acquire rights to land for the necessary holding ponds within their own jurisdictions, and designate the necessary floodways. Selection of Alternative Plan II is, of course, contingent upon the decision of the sponsoring agencies of the PL-566 project.

The City of Auburn has major jurisdictional and economic responsibiility for control of urban drainage and related flood damage problems in the sub-area. Therefore, it is recommended that Auburn and King County share primary responsibility for control of drainage and flood damage in the Mill Creek sub-area.

EARLY ACTION

In addition to the immediate need for development of a drainage master plan and designation of jurisdictional leadership within this demonstration area, certain physical features of the alternative plans, presented herein, appear to be generally applicable to any drainage plan which may be forthcoming as well as both suitable and desirable for early implementation within the next ten-year period. These features are presented in the three categories previously defined.

FACILITY RECOMMENDATIONS

The basic recommendation for this demonstration area is that of providing a pumping plant, or plants, to discharge runoff waters into the Green River. The properties along Auburn Way North are periodically flooded and require immediate action. However, a decision by local citizens must be made as to the alternative they want to pursue before action can be taken on either of these items.

Design and construction could proceed for the following elements prior to deciding upon either of the foregoing items.

Category I - Common Alternative Elements

Element Number	Proposed Facility	Estimated Capital Cost
506	30" pipe - 780'	$ 42,000
339	36" pipe - 280'	18,000
505	36" pipe - 340'	22,000
338	42" pipe - 2000'	157,000
508	36" pipe - 260'	16,000
378	36" pipe - 100'	12,000
	TOTAL	$267,000

Category II - Alternative Elements Common in Scope

None

Category III - Response to Reported Drainage Problems

None in addition to those reported in Category I.

EVALUATION MATRIX

MILL CREEK DEMONSTRATION AREA

ALTERNATIVES	EFFECTIVENESS SUB TOTAL	Use of existing facilities	System reliability	System maintainability	System flexibility	Flood damage reduction	Consequences of overcharge	Erosion and sedimentation control	Cost/benefits ranking	HUMAN VALUES SUB TOTAL	Urban quality (aesthetics)	Effect on land use	Displacement of people	Educational value	Community cohesion	Multiple use potential	Public health and safety	ENVIRONMENTAL FACTORS SUB TOTAL	High flow conditions	Alteration of natural system	Effects on groundwater	Low flow conditions	Water quality	Construction disruption	Effects on wildlife	Effects on aquatic life	Effects on vegetation	IMPLEMENTATION SUB TOTAL	Legislative requirements	Jurisdictional	Land acquisition	Public acceptance	Financing	Effects of no action	RESOURCE REQUIREMENTS SUB TOTAL	Energy	Materials	Land	Capital	RATING TOTAL
CRITERIA WEIGHT		1	4	3	2	4	4	4	2		4	2	2	1	3	3	4		4	4	4	4	4	2	4	4	4		4	4	2	4	4	3		3	3	2	2	
I	-12	-1 -1	-1 -4	-1 -3	-1 -2	+1 +4	-1 -4	0	-1 -2	- 3	-1 -4	+1 +2	+1 +2	0	0	-1 -3	0	-22	-1 -4	-1 -4	0	0	0	-1 -2	-1 -4	-1 -4	-1 -4	- 3	0	-1 -4	-1 -2	0	0	+1 +3	-7	-1 -3	0	-1 -2	-1 -2	-47
II	+ 6	+1 +1	-1 -4	-1 -3	+1 +2	+1 +4	+1 +4	+1 +4	-1 -2	+11	0	+1 +2	+1 +2	+1 +1	+1 +3	+1 +3	0	+ 2	0	0	-1 -4	+1 +4	0	-1 -2	-1 -4	+4 +4	+1 +4	- 6	0	-1 -4	-1 -2	0	0	0	-3	-1 -3	0	+1 +2	-1 -2	+10
III	- 8	-1 -1	-1 -4	-1 -3	-1 -2	+1 +4	-1 -4	+1 +4	-1 -2	- 6	-1 -4	+1 +2	+1 +2	0	-1 -3	-1 -3	0	-26	-1 -4	-1 -4	-1 -4	0	0	-1 -2	-1 -4	-1 -4	-1 -4	+17	+1 +4	+1 +4	-1 -2	+1 +4	+1 +4	+1 +3	-7	-1 -3	0	-1 -2	-1 -2	-30

RUNOFF QUALITY SUMMARY
MILL CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 5 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
South 37th St. at Mill Creek	Present Land Use	50	8	2.9×10^4	.2	.7	.2
	2000 Comprehensive Land Use I	280	13	2.8×10^5	.5	1.0	.1
	II	280	13	2.8×10^5	.5	1.0	.1
	III	40	12	5.5×10^4	.6	1.6	.2
Peasley Canyon	Present Land Use	170	1	1.9×10^4	.02	.1	.03
	2000 Comprehensive Land Use I	420	8	1.7×10^5	.2	.6	.1
	II	300	2	4.6×10^4	.1	.2	.1
	III	420	8	1.7×10^5	.2	.6	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

RUNOFF QUALITY SUMMARY
MILL CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 5 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW* BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth of Mill Creek	Present Land Use**	300	3	1.4×10^4	.1	.4	.1
	2000 Comprehensive Land Use						
	I	1400	5	6.7×10^4	.2	.6	.1
	II	1100	5.3	6.1×10^4	.2	.5	.1
	III (P-4)	1300	5	3.9×10^4	.2	.5	.1
	(P-7)	320	7	1.3×10^5	.3	.6	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.
** Concentrations are approximate.

RUNOFF QUALITY SUMMARY
MILL CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
South 37th St. at Mill Creek	Present Land Use Existing Conditions	50	22	8.7×10^4	.7	2.0	.1
	2000 Comprehensive Land Use						
	I	280	.38	8.3×10^5	1.5	3.2	.3
	II	40	38	8.3×10^5	1.5	3.2	.3
	III	280	4	1.8×10^4	.2	.5	.1
Peasley Canyon	Present Land Use Existing Conditions	170	3	5.9×10^4	.1	.3	.1
	2000 Comprehensive Land Use						
	I	420	3	5.5×10^4	.1	.2	.1
	II	300	9	1.9×10^5	.2	.7	.3
	III	420	3	5.5×10^4	.1	.2	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

RUNOFF QUALITY SUMMARY
MILL CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW* BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth of Mill Creek	Present Land Use** Existing Conditions	300	4	2.0×10^4	.1	.6	.05
	2000 Comprehensive Land Use						
	I	1400	16	2.0×10^5	.6	1.7	.2
	II	1100	16	1.8×10^5	.6	1.6	.2
	III (P-4)	1300	14	1.2×10^5	.5	1.5	.2
	(P-7)	320	21	3.9×10^5	.9	1.9	.2

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.
** Concentrations are approximate.

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Mill Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
311	Channel	20'	1,200'	2:1	20'	Channel	40' width 12' depth 3:1 side slopes	$221,000
Pump Station 311	Outlet					Pump Station	1,250 cfs Pump station	$2,250,000
66	Channel	20'	5,350'	2:1	7'	Channel	20' width 10' depth 2:1 side slopes Bank protection	$623,000
314	Channel	7'	1,600'	2:1	7'	Channel	20' width 10' depth 2:1 side slopes Bank protection	$215,000
500	Channel	9'	2,000'	1:1	7'	Channel	20' width 10' depth 2:1 side slopes	$137,000
317	Culvert	14'	200'	0	8'	Parallel Culvert	14' x 8'	$98,000
67	Channel	10'	2,100'	2:1	8'	Channel	20' width 9' depth 2:1 side slopes	$66,000
320	Culvert	12'	190'	0	7'	Parallel Culvert	12' x 7'	$80,000
80	Conduit	1.5'	200'	0	0	Parallel Channel	6' width 5' depth 1:1 side slopes Bank protection	$12,000
322	Conduit	4'	500'	0	0	Parallel Channel	6' width 5' depth 1:1 side slopes Bank protection	$29,000
323	Conduit	4'	900'	0	0	Parallel Channel	6' width 4' depth 1:1 side slopes Bank protection	$44,000
82	Conduit	4'	1,100'	0	0	Parallel Channel	6' width 4' depth 1:1 side slopes Bank protection	$53,000
83	Conduit	4'	500'	0	0	Parallel Channel	6' width 4' depth 1:1 side slopes Bank protection	$24,000
84	Conduit	3.5'	2,500'	0	0	Parallel Channel	6' width 4' depth 1:1 side slopes Bank protection	$121,000
331	Pipe	36"	1,200'			Parallel Pipe	48"	$109,000
332	Pipe	30"	700'			Parallel Pipe	48"	$64,000
85	Pipe	24"	1,200'			Parallel Pipe	48"	$109,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Mill Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
334	Pipe	27"	350'			Parallel Pipe	42"	$28,000
335	Pipe	1.5'	1,100'			Parallel Pipe	42"	$55,000
86	Pipe	1'	1,100'			Parallel Pipe	36"	$72,000
328	Pipe	2'	600'			Parallel Pipe	42"	$47,000
329	Pipe	1.75'	1,600'			Parallel Pipe	42"	$126,000
324	Pipe	1.75'	30'			Parallel Pipe	54" 50' Includes inlet & outlet	$13,000
501	Pipe	60"	100'			Parallel Pipe	54"	$11,000
375	Channel	4'	1,000'	3:1	4'	Channel	8' width 5' depth 1:1 side slopes Bank protection	$49,000
376	Pipe	48"	30'			Parallel Culvert	12' x 5' 50'	$19,000
76	Channel	4'	2,500'	3:1	4'	Channel	6' width 4' depth 1:1 side slopes Bank protection	$121,000
336	Pipe	18"	30'			Parallel Culvert	8' x 4' 50'	$13,000
338	Pipe	18"	2,000'			Parallel Pipe	42"	$157,000
505	Pipe	18"	340'			Parallel Pipe	36"	$22,000
339	Pipe	15"	280'			Parallel Pipe	36"	$18,000
506	Pipe	12"	780'			Parallel Pipe	30"	$42,000
68	Channel	7'	2,200'	3:1	6'	Channel	18' width 8' depth 2:1 side slopes	$62,000
341	Culvert	13'	50'	0	7'	Parallel Culvert	13' x 7'	$22,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Mill Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
342	Channel	7'	2,700'	3:1	6'	Channel	18' width 8' depth 2:1 side slopes	$76,000
343	Pipe	96"	200'			Parallel Culvert	Two-96" with inlet & outlet	$114,000
69	Channel	6'	2,600'	1:1	6'	Channel	18' width 8' depth 2:1 side slopes	$70,000
344	Channel	8'	180'	Vertical	6'	Parallel Culvert	12' x 6'	$72,000
345	Channel	5'	4,800'	1:1	6'	Channel	18' width 8' depth 2:1 side slopes	$239,000
378	Pipe	18"	100'			Parallel Pipe	36" Includes inlet & outlet	$12,000
508	Pipe	15"	260'			Parallel Pipe	36"	$16,000
347	Channel	2'	1,930'	2:1	1'	Replacement Pipe	24"	$71,000
355	Pipe	96"	150'			Parallel Culvert	18' x 6'	$80,000
356	Channel	10'	70'	2:1	8'	Channel	Bank protection	$5,000
71	Pipe	96"	310'			Parallel Culvert	18' x 6'	$165,000
512	Pipe	36"	330'			Parallel Culvert	8' x 4'	$86,000
514	Channel	3'	1,300'	1:1	4'	Channel	4' width 4' depth 2:1 side slopes	$7,000
572	Channel	8'	200'	2:1	8'	Channel	Bank protection	$7,000
509	Channel	7'	3,540'	2:1	7'	Channel	Bank protection	$114,000
121	Pipe	36"	260'			Parallel Pipe	42"	$20,000
510	Channel	8'	3,600'	3:1	4'	Drop inlets	14 drop inlet box structures	$41,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Mill Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
360	Channel	4'	5,000'	2:1	4'	Drop Inlets	16 drop inlet box structures	$47,000
369	Channel	8'	3,600'	3:1	4'	Drop Inlets	16 drop inlet box structures	$47,000
622	Lake Dolloff Outlet					Outlet	Concrete weir & spillway with 2' gated outlet	$4,000
621	Lake Geneva Outlet					Outlet	Concrete weir & spillway with 2' gated outlet	$4,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $6,429,000

Round To: $6,400,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Mill Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
311	Channel	20'	1,200'	2:1	20'	Channel	130' width 4.5' depth 3:1 side slopes	$95,000
66	Channel	20'	5,350'	2:1	7'	Channel	60' width 7' depth 3:1 side slopes	$699,000
314	Channel	7'	1,600'	2:1	7'	Channel	60' width 7' depth 3:1 side slopes	$209,000
316	Channel	20'	550'	3:1	7'	Channel	60' width 7' depth 3:1 side slopes	$72,000
500	Channel	9'	2,000'	1:1	7'	Channel	20' width 10' depth 2:1 side slopes	$137,000
317	Culvert	14'	200'	0	8'	Parallel Culvert	14' x 8'	$98,000
318	Channel	19'	500'	3:1	7'	Channel	60' width 7' depth 3:1 side slopes	$65,000
67	Channel	10'	2,100'	3:1	8'	Channel	60' width 7' depth 3:1 side slopes	$274,000
320	Culvert	12'	190'	0	7'	Parallel Culvert	12' x 7'	$80,000
68	Channel	7'	2,200'	3:1	6'	Channel	40' width 3:1 side slopes	$201,000
80	Pipe	18"	200'			Parallel Channel	6' width 5' depth 1:1 side slopes Bank protection	$12,000
322	Pipe	48"	500'			Parallel Channel	6' width 5' depth 1:1 side slopes Bank protection	$29,000
323	Pipe	48"	900'			Parallel Channel	6' width 4' depth 1:1 side slopes Bank protection	$44,000
82	Pipe	48"	1,100'			Parallel Channel	6' width 4' depth 1:1 side slopes Bank protection	$53,000
83	Pipe	48"	500'			Parallel Channel	6' width 4' depth 1:1 side slopes Bank protection	$24,000
84	Pipe	42"	2,500'			Parallel Channel	6' width 4' depth 1:1 side slopes Bank protection	$121,000
331	Pipe	36"	1,200'			Parallel Conduit	48"	$109,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Mill Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
332	Pipe	30"	700'			Parallel Conduit	48"	$64,000
85	Pipe	24"	1,200'			Parallel Pipe	48"	$109,000
334	Pipe	21"	350'			Parallel Pipe	42"	$28,000
335	Pipe	18"	700'			Parallel Pipe	42"	$55,000
86	Pipe	12"	1,100'			Parallel Pipe	36"	$72,000
328	Pipe	24"	600'			Parallel Pipe	42"	$47,000
329	Pipe	21"	1,600'			Parallel Pipe	42"	$126,000
324	Pipe	21"	30'		1.75'	Parallel Pipe	54" 50' Includes inlet & outlet	$13,000
501	Pipe	60"	100'			Parallel Pipe	54"	$11,000
375	Channel	4'	1,000	3:1	4'	Channel	8' width 5' depth 1:1 side slopes Bank protection	$49,000
376	Pipe	48"	30'			Parallel Culvert	12' x 5' 50'	$19,000
76	Channel	4'	2,500'	3:1	4'	Channel	6' width 4' depth 1:1 side slopes Bank protection	$121,000
336	Pipe	18"	30'			Parallel Culvert	8' x 4' 50'	$13,000
338	Pipe	18"	2,000'			Parallel Pipe	42"	$157,000
505	Pipe	18"	340'			Parallel Pipe	36"	$22,000
339	Pipe	15"	280'			Parallel Pipe	36"	$18,000
506	Pipe	12"	780'			Parallel Pipe	30"	$42,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II   Sub-Basin Mill Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES TYPE		ESTIMATED CAPITAL COST
341	Culvert	13'	50'	Vertical	7'	Parallel Culvert	8' x 7'	$19,000
343	Pipe	8'	200'			Parallel Pipe	96" with inlet & outlet	$57,000
344	Culvert	8'	180'	0	6'	Parallel Culvert	10' x 6'	$64,000
342	Channel	7'	2,700'	3:1	6'	Channel	40' width 5' depth 3:1 side slopes	$224,000
69	Channel	6'	2,600'	1:1	6'	Channel	40' width 3' depth 3:1 side slopes	$122,000
345	Channel	5'	4,800'	1:1	6'	Channel	40' width 3' depth 3:1 side slopes	$224,000
378	Pipe	18"	100'			Parallel Pipe	36" with inlet & outlet	$12,000
508	Pipe	15"	260'			Parallel Pipe	36"	$16,000
355	Pipe	96"	150'			Parallel Pipe	Two-96"	$93,000
356	Channel	10'	70'	2:1	8'	Channel	Bank protection	$5,000
71	Pipe	96"	310'			Parallel Pipe	Two-96"	$128,000
512	Pipe	36"	330'			Parallel Culvert	8' x 4'	$86,000
514	Channel	3'	1,300'	1:1	4'	Channel	4' width 4' depth 2:1 side slopes	$7,000
640	None					Channel	4' width 4' depth 2:1 side slopes 4,000'	$52,000
641	None					Channel	4' width 4' depth 2:1 side slopes 4,800'	$63,000
642	None					Channel	4' width 4' depth 2:1 side slopes 4,000'	$52,000
644	None					Channel	4' width 4' depth 2:1 side slopes 2,600'	$34,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Mill Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
645	None					Channel	4' width 6' depth 2:1 side slopes 5,500'	$136,000
646	None					Channel	4' width 6' depth 2:1 side slopes 1,600'	$40,000
647	None					Channel	4' width 6' depth 2:1 side slopes 4,000'	$99,000
648	None					Channel	4' width 6' depth 2:1 side slopes 7,000'	$173,000
640p	None					Pump Station	30 cfs	$65,000
641p	None					Pump Station	70 cfs	$151,000
642p	None					Pump Station	60 cfs	$129,000
644p	None					Pump Station	50 cfs	$108,000
645p	None					Pump Station	80 cfs	$172,000
646p	None					Pump Station	140 cfs	$301,000
647p	None					Pump Station	160 cfs	$344,000
648p	None					Pump Station	170 cfs	$365,000
621	Lake Geneva					Outlet	Concrete weir & spillway	$4,000
622	Lake Dolloff					Outlet	Concrete weir & spillway	$4,000
521	Channel	6'	2,150'	1:1	3'	Holding Pond	5 AF 1.83 acres	$26,000
655	None					Holding Pond	20 AF 3 acres	$33,000
663						Holding Pond	4 AF 1.83 acres	$26,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Mill Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
661	None					Holding Pond	4 AF 1.83 acres	$26,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $6,748,000

Round To: $6,700,000

Alternative III Sub-Basin Mill Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES TYPE		ESTIMATED CAPITAL COST
P-4 & P-7 Pump Stations	Proposed PL-566 Watershed Project Allocated to Mill Creek					Pump Station	1,250 cfs	$1,543,000**
P-4 & P-7 Channel Systems	Proposed PL-566 Watershed Project Allocated to Mill Creek					Channel	Includes P-4, 4A, 4B, 13, 14, 11, 15, 16, P-7 and P-8	$2,693,000**
355	Pipe	96"	150'			Parallel Pipe	Three-96"	$139,000
356	Channel	10'	70'	2:1	8'	Channel	Bank protection	$5,000
71	Pipe	96"	310'			Parallel Pipe	Two-96"	$128,000
572	Channel	8'	200'	2:1	8'	Channel	Bank protection	$7,000
509	Channel	8'	3,540'	2:1	7'	Channel	Bank protection	$114,000
360	Channel	4'	5,000'	2:1	4'	Drop Inlets	16 drop inlet box structures 5' head loss	$47,000
621	No existing outlet control - Lake Geneva					Outlet	Concrete weir spillway gated 2' diameter outlet	$4,000
121	Pipe	36"	258'			Parallel Pipe	42"	$20,000
510	Channel	8'	3,600'	3:1	4'	Drop Inlets	14 drop inlet box structures 5' head loss	$41,000
369	Channel	4'	4,550'	2:1	4'	Drop	16 drop inlet box structures 5' head loss	$47,000
622	No existing outlet control - Lake Dolloff					Outlet	Concrete weir spillway with 2' gated outlet	$4,000
378	Pipe	18"	100'			Parallel Pipe	36" with inlet and outlet	$12,000
508	Pipe	15"	260'			Parallel Pipe	36"	$16,000
347	Channel	2'	1,930'	2:1	1'	Diversion Pipe	24"	$71,000
338	Pipe	18"	2,000'			Parallel Pipe	42"	$157,000

** Represents that portion of the total pumping plant and channel costs required to accommodate runoff from Mill Creek. The other portion is included in the Lower Green River Sub-Basin costs.

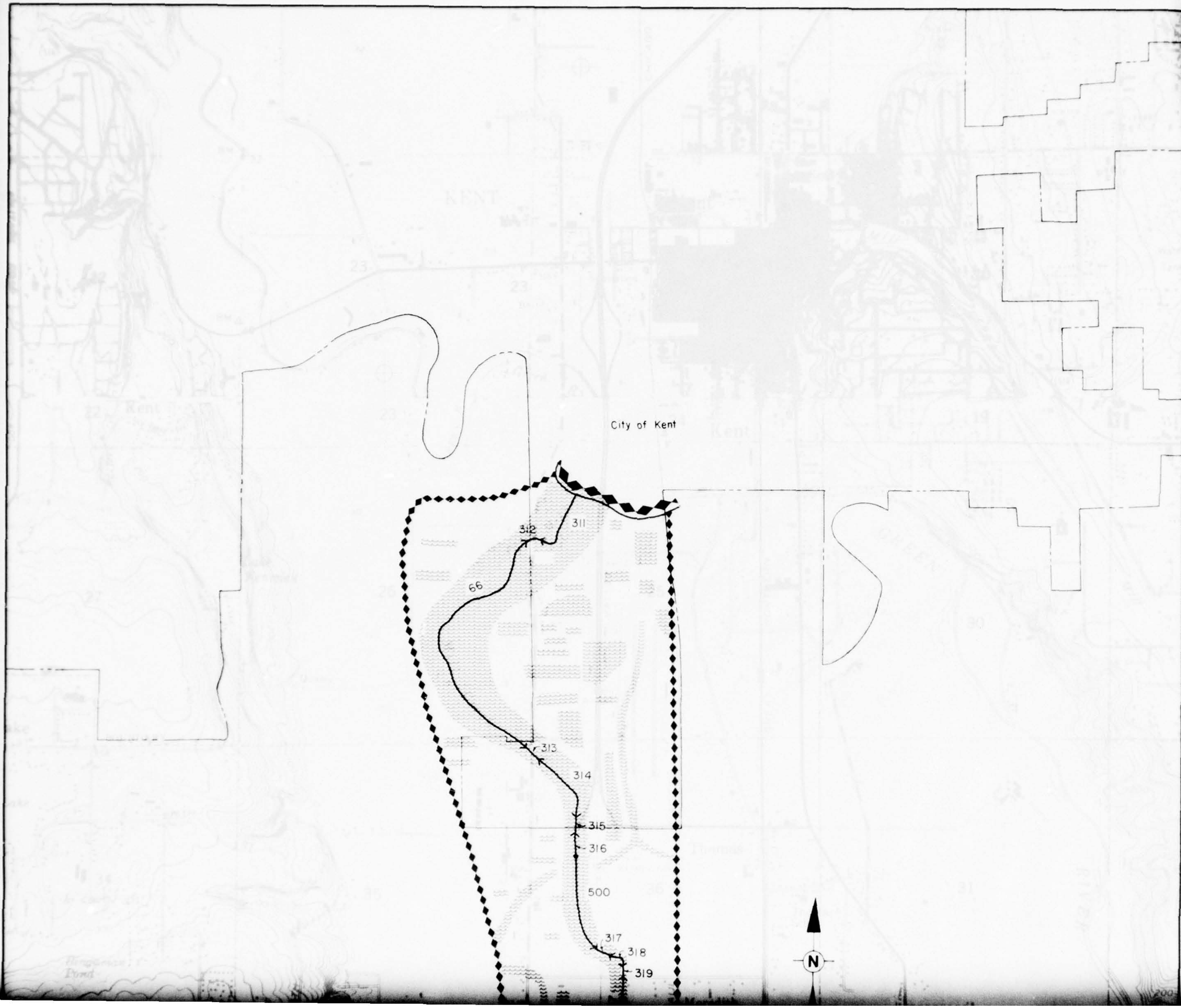
RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative III Sub-Basin Mill Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
505	Pipe	18"	340'			Parallel Pipe	36"	$22,000
339	Pipe	15"	280'			Parallel Pipe	36"	$18,000
506	Pipe	12"	780'			Parallel Pipe	30"	$42,000
82	Pipe	48"	1,100'			Parallel Pipe	6' width 4' depth 1:1 side slopes Bank protection	$53,000
83	Pipe	48"	500'			Parallel Channel	6' width 4' depth 1:1 side slopes Bank protection	$24,000
84	Pipe	42"	2,500'			Parallel Channel	6' width 4' depth 1:1 side slopes Bank protection	$121,000
331	Pipe	36"	1,200'			Parallel Pipe	48"	$109,000
332	Pipe	30"	700'			Parallel Pipe	48"	$64,000
85	Pipe	24"	1,200'			Parallel Pipe	48"	$109,000
334	Pipe	21"	350'			Parallel Pipe	42"	$28,000
335	Pipe	18"	700'			Parallel Pipe	42"	$55,000
86	Pipe	12"	1,100'			Parallel Pipe	36"	$72,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $5,765,000
Round To: $5,800,000



City of Kent
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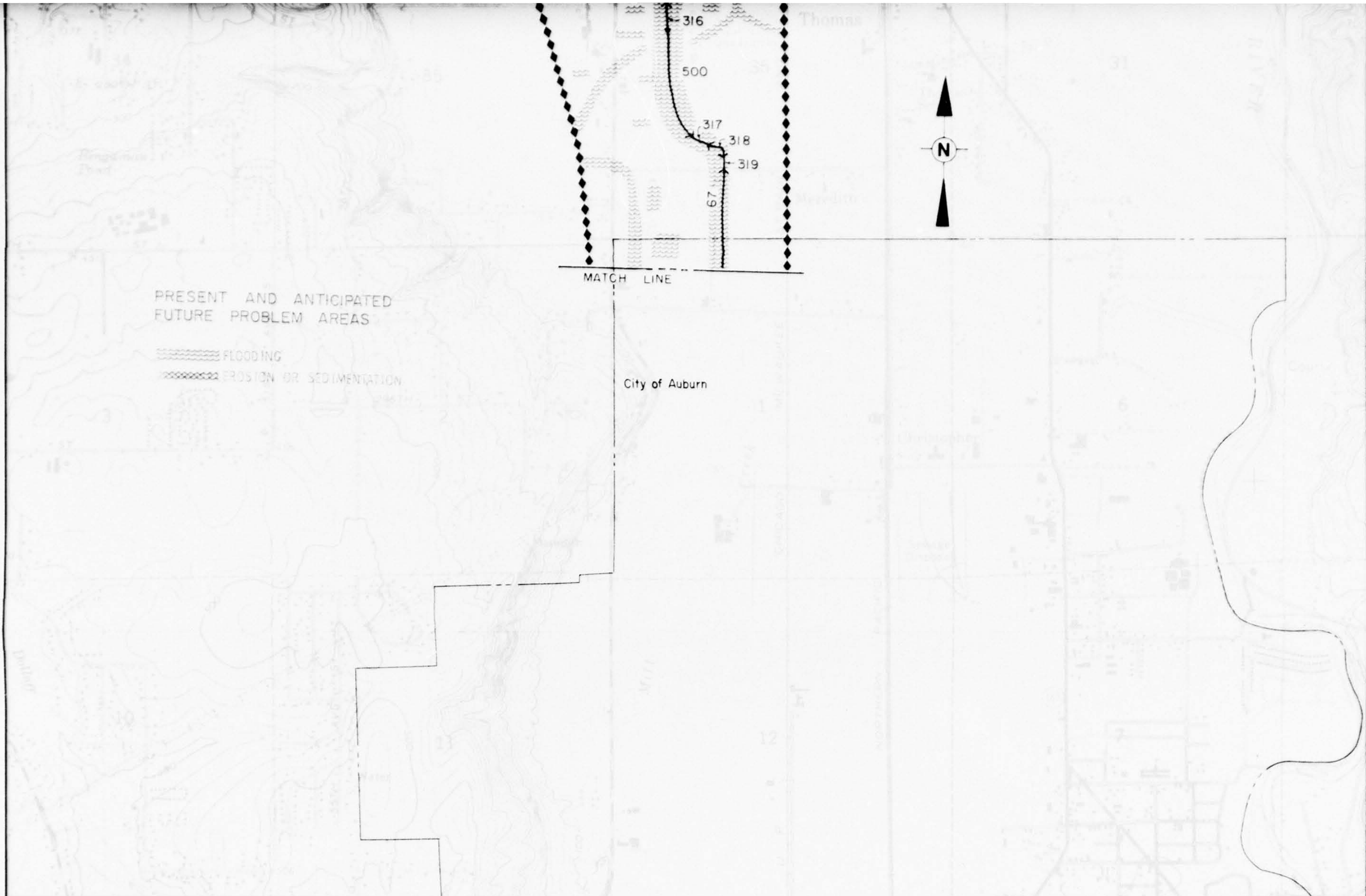

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER GREEN RIVER

MILL CREEK DEMONSTRATION AREA

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26-1-161 SHEET 1a OF 2

2

MATCH LINE
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Meredith
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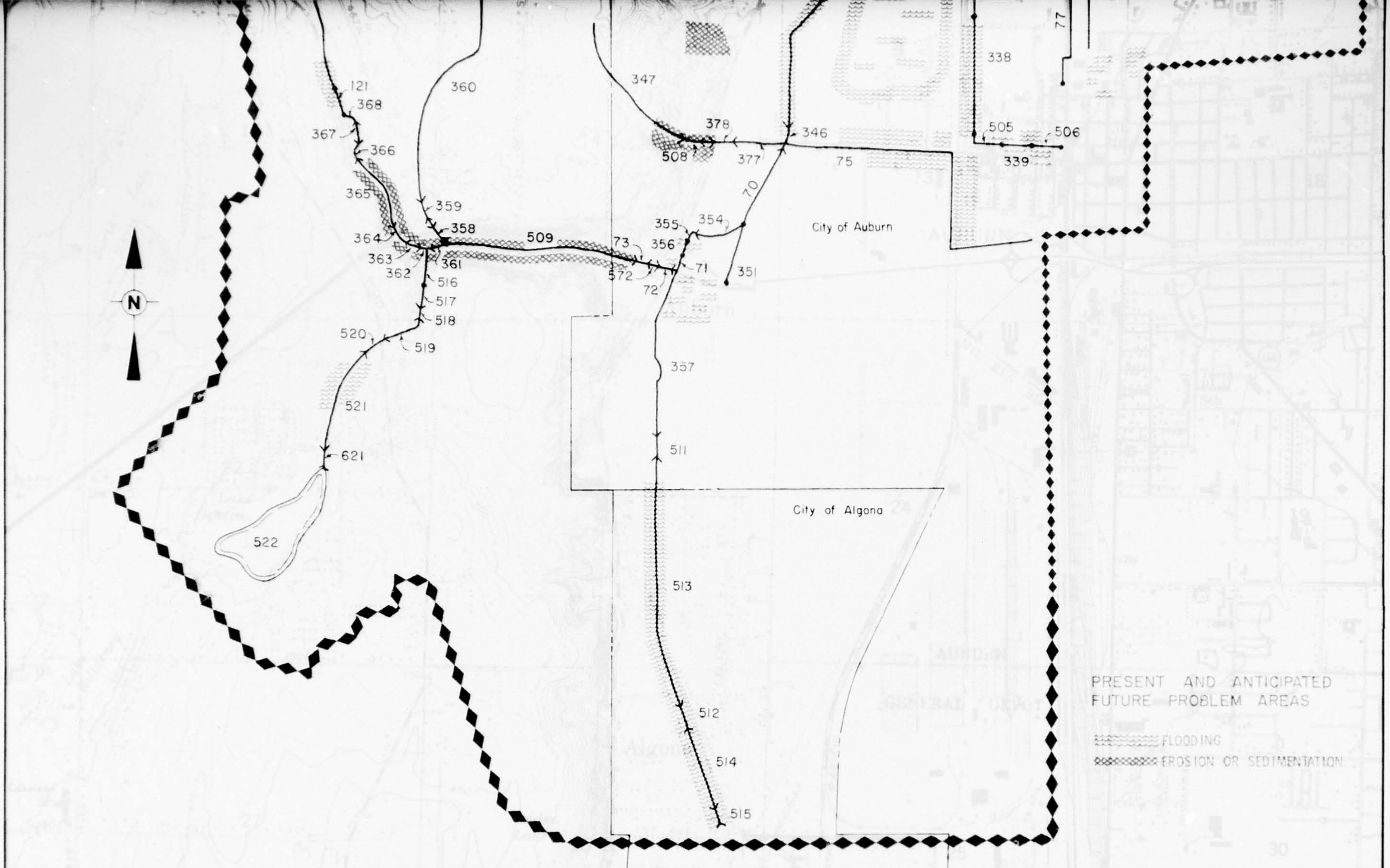

LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE

CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER GREEN RIVER

MILL CREEK DEMONSTRATION AREA

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC.
WATER RESOURCES ENGINEERS, INC.
YODER, TROTTER, ORLOB & ASSOCIATES

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DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 2 OF 2


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URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER GREEN RIVER

MILL CREEK DEMONSTRATION AREA

PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
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DATE AUGUST, 1974 FILE NO. E-26-1-161 SHEET 1b OF 2


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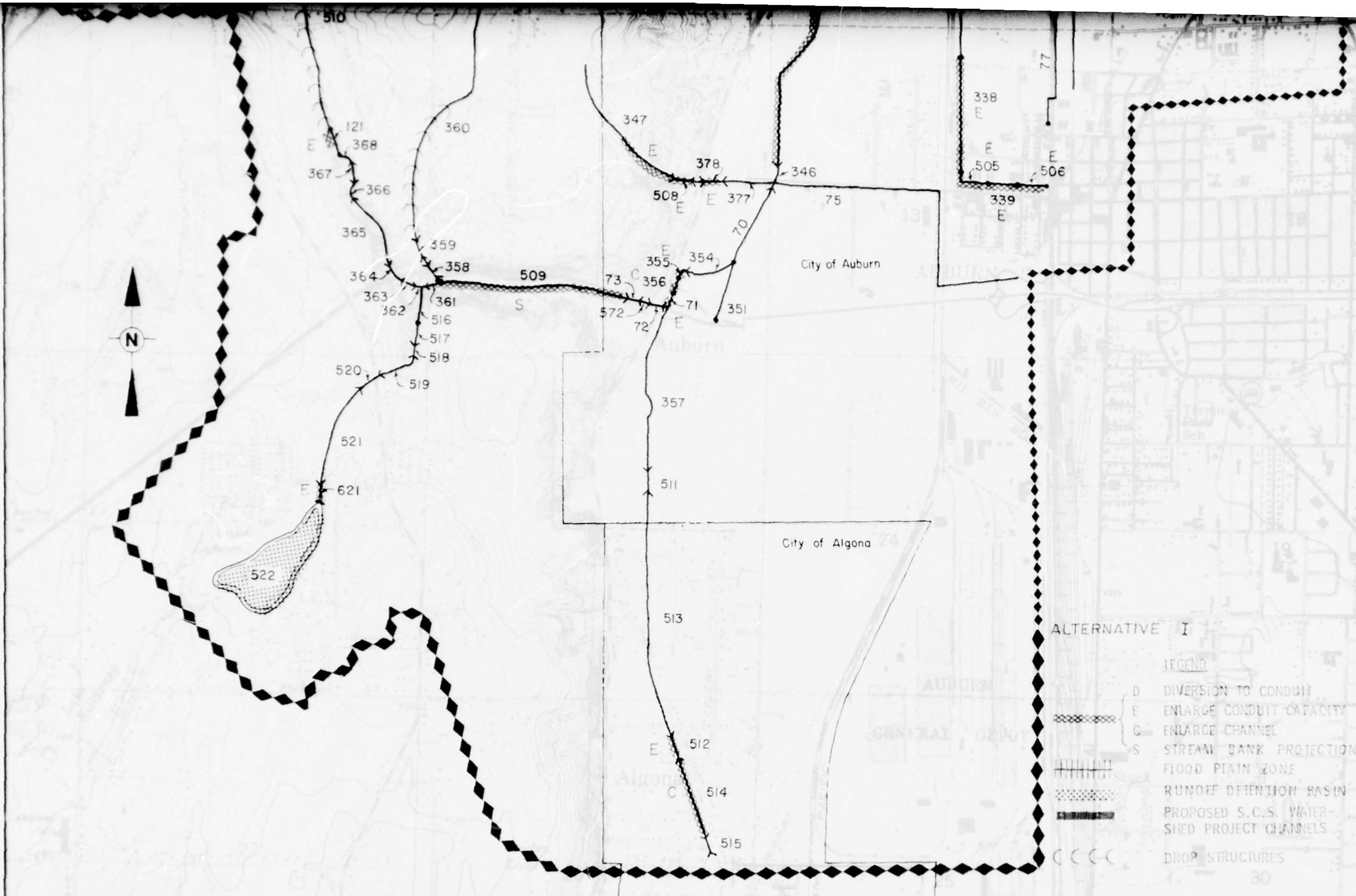

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REVISIONS

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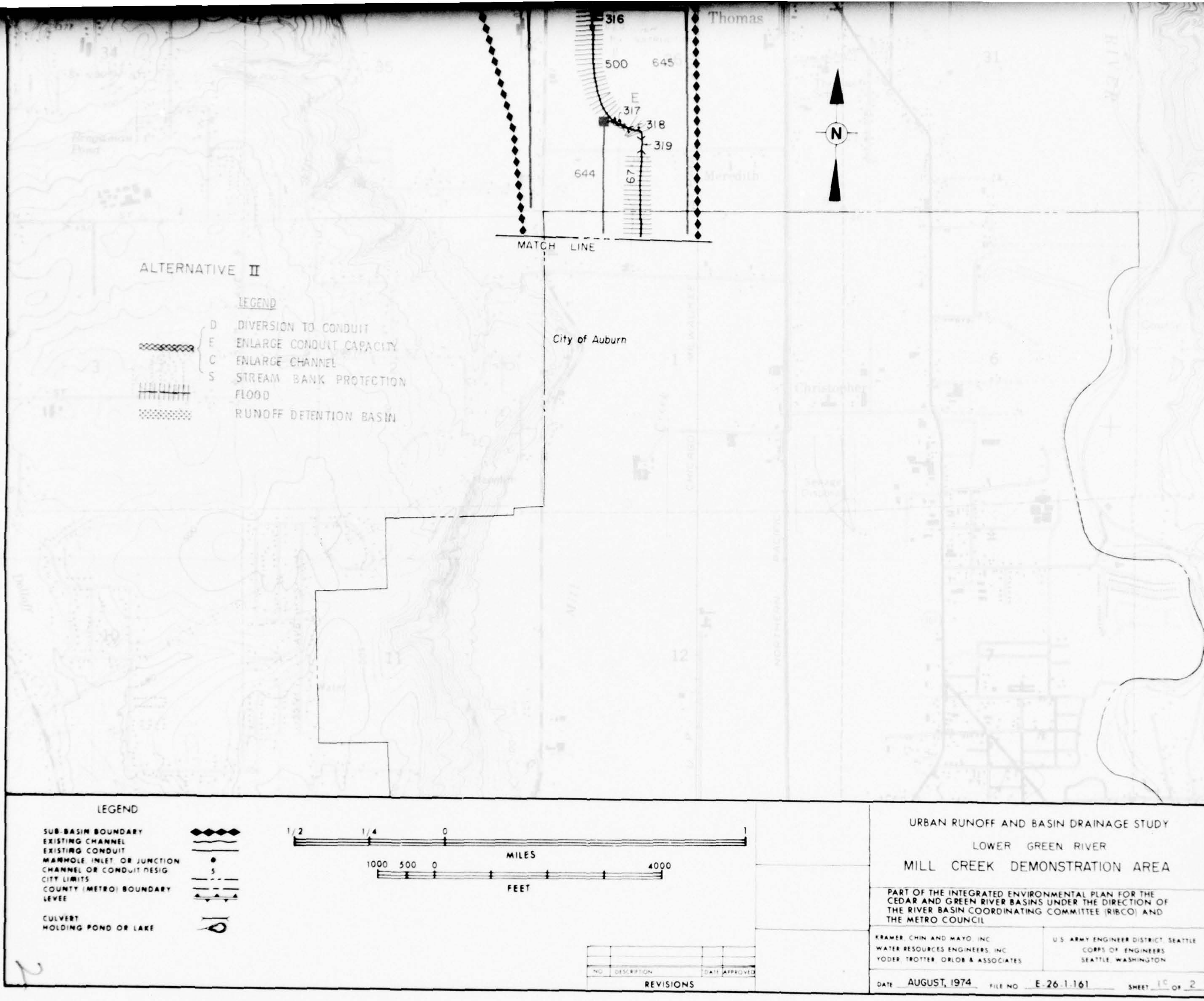
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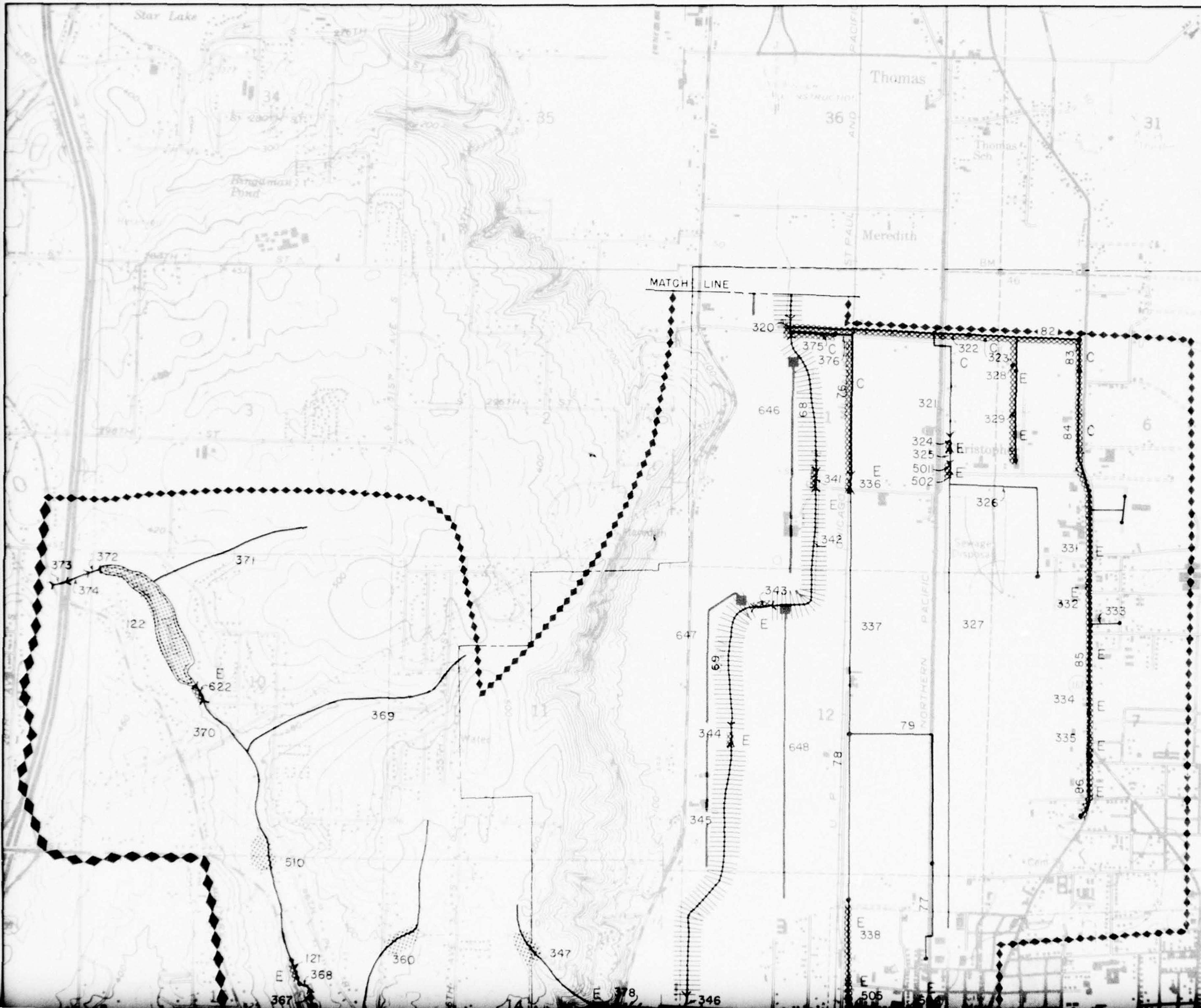

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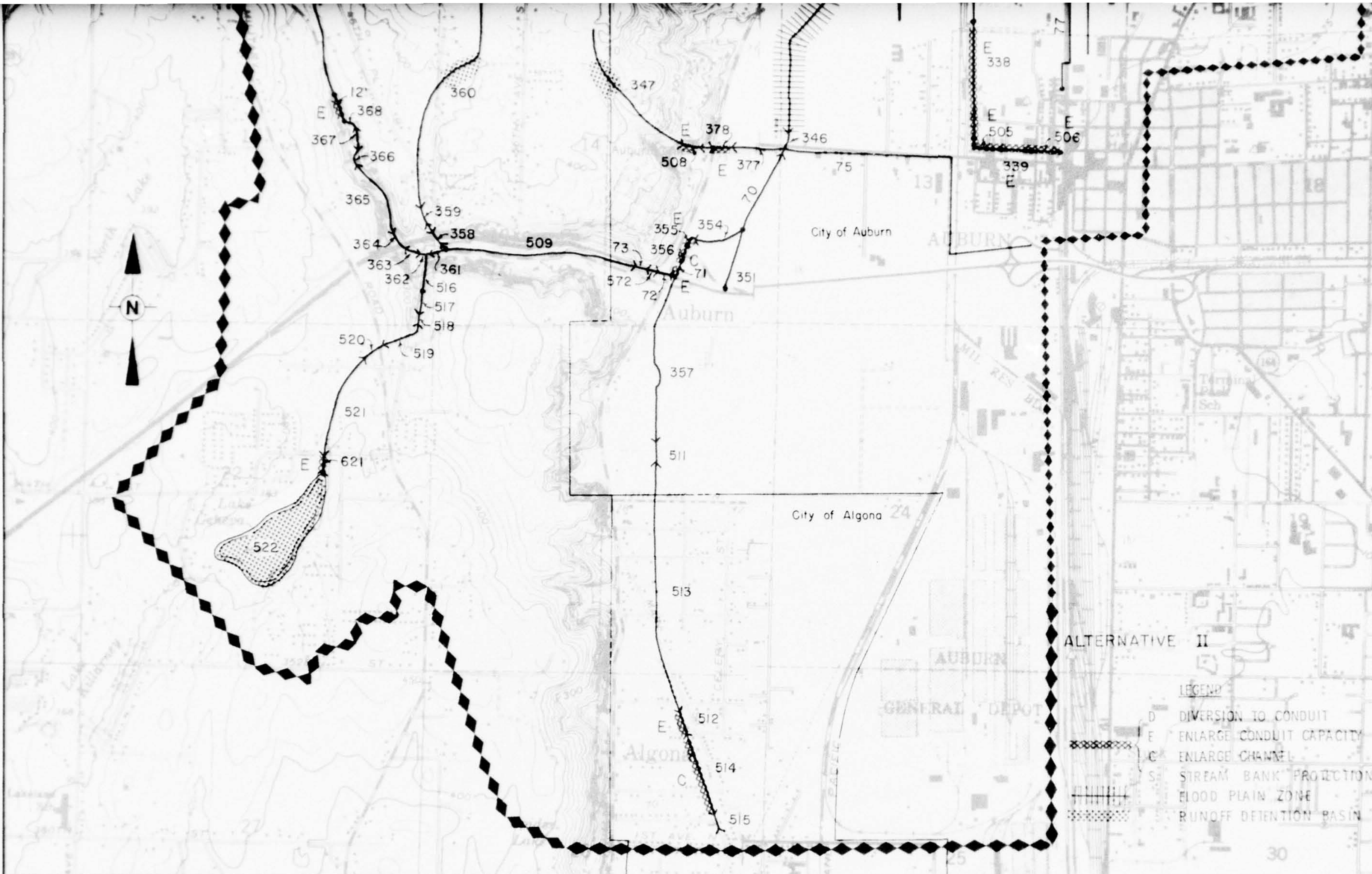

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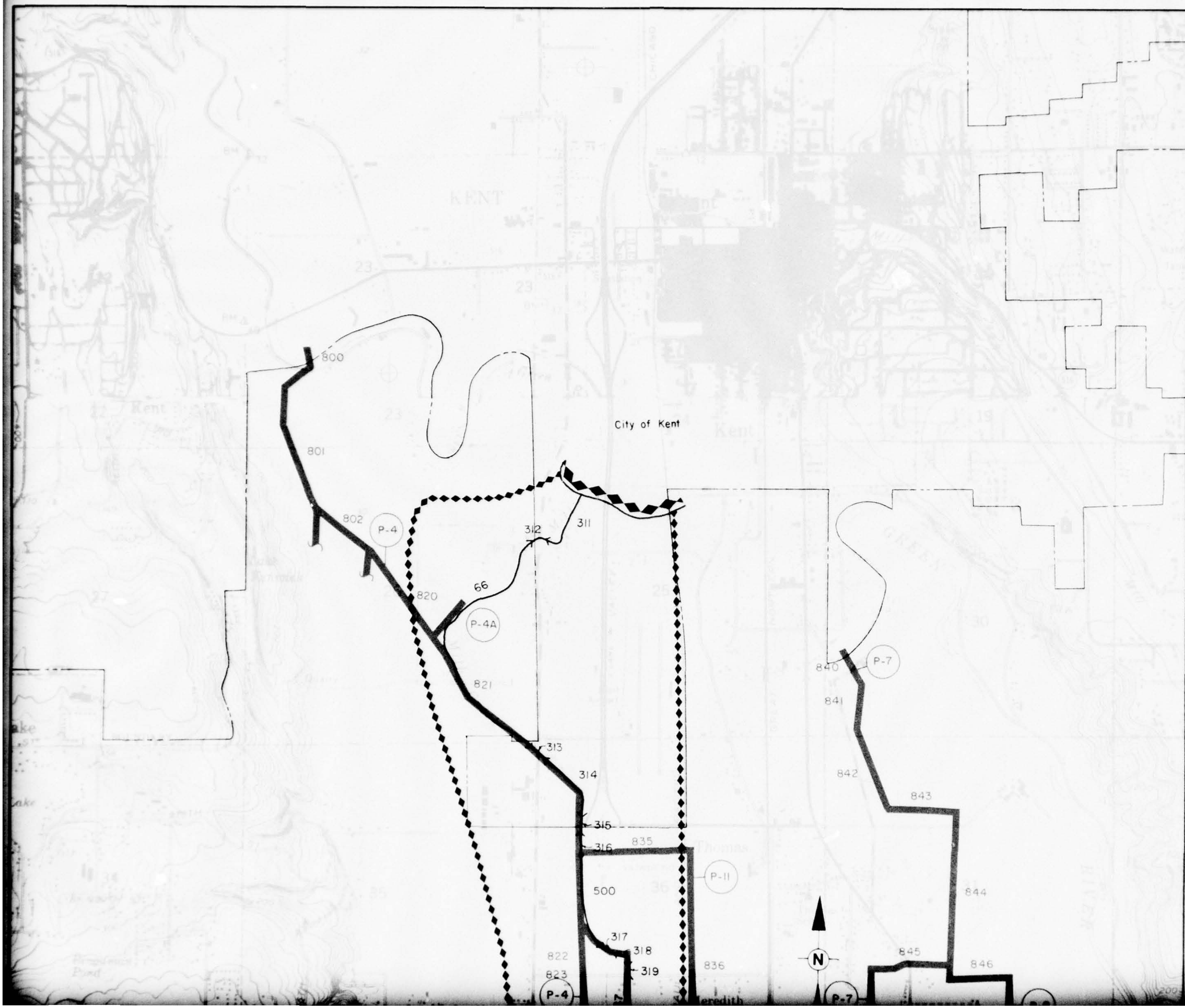

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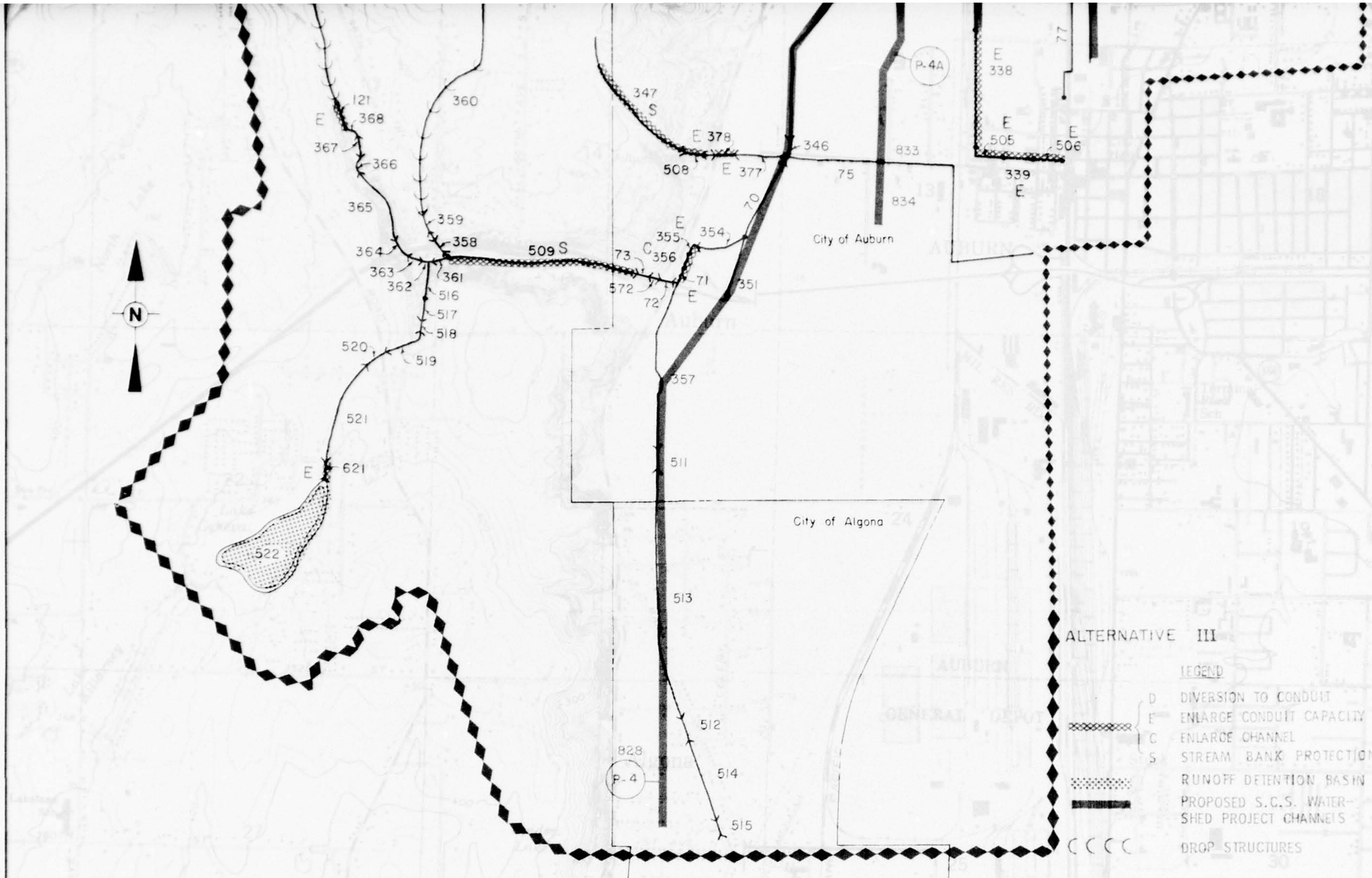

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REGIONAL SUB-BASIN P-3

MILLER CREEK DEMONSTRATION AREA

GENERAL DESCRIPTION

The Miller Creek sub-area is located on Puget Sound north and west of the Seattle-Tacoma Airport. The stream flows south and southwest and drains the mid-upper portion of the Lower Puget Sound Sub-Basin (see separate evaluation for the Lower Puget Sound Sub-Basin).

The geography of the sub-area is variable. There is a plateau area, with eroded valleys along the seaward side that are created by overland flow. The sub-area also has numerous land sinks or depressions, an ancient glacial feature that is predominate throughout the Puget Sound area. The sub-area boundaries are delineated primarily by natural features, such as hill crest lines and saddles. Where the sub-area boundary passes through urbanized areas, man-made features (street gutters, etc.) align the watershed boundary. Numerous small streams flow into Miller Creek and/or the natural sinks within the sub-area.

Stream	Category	Drainage Area	Discharge
Miller	III	8.9 sq. mi.	Puget Sound

Miller Creek may be considered a floodway-zone stream throughout most of its reach, with a pastoral zone in the upland bog and marsh areas. This creek drains from Arbor Lake southerly to the northwest corner of the airport, then southwesterly to its outflow into Puget Sound. Principal features of the sub-area are the Burien commercial area; Sea-Tac Airport, and the highway system SR509 and SR518. There is no gaging station for this stream. The drainage area is approximately nine square miles and the stream extends the entire length of the sub-area, changing in elevation about 400 feet as measured from the Arbor Lake area to Puget Sound.

Land-use development is tabulated in the table below for existing conditions (1970-1972), and for the projected year 2000 Comprehensive and Corridor Land Use Plans. Single-family residential development is the predominant land use for all three categories. The projected trend will be for a 3 percent reduction in single-family units, and 3 percent increase in multiple family use. All existing vacant land (2%) will be altered by development by the year 2000.

PERCENT OF SUB-AREA IN SPECIFIED LAND USES

Land Use	Existing (1970-72)	P.S.G.C. Land Use Projection Comprehensive	Corridor
Single Family	75	72	72
Multiple Family	5	8	8
Commercial/Services	7	8	8
Govt. and Educ.	2	2	2
Industrial	1	1	1
Parks/Dedicated Open Space	5	5	5
Agriculture			
Airports, Railyards, Freeways, Highways	3	4	4
Unused Land	2	0	0
Water			
Total	100	100	100
Total Impervious	35	36	36

Jurisdictions in the sub-area are King County, Port of Seattle, and the City of Normandy Park. Only a small portion of the sub-area is serviced by Metro. The community of Burien is within the sub-area. Small special-interest groups and concerned individuals in the sub-area have expressed interest in helping to plan future action to curb detrimental effects upon the natural streams such as water pollution and land erosion. One such citizen agency is the King County Environmental Development Commission. Another (that is working with King County on drainage problems) is the Miller Creek Drainage Basin Committee.

NATURE OF EXISTING DRAINAGE SYSTEM

The nature of the drainage systems are fairly similar throughout the entire sub-area. This is due to the predominate land-use, single-family residential. There are several lakes and numerous "pot holes" or sinks that act as storage ponds during wet weather. There are wetlands within the sub-area consisting of marshes and bogs in level lowlands and lake perimeters that act to moderate runoff rates.

Man-made facilities in the drainage system consist primarily of street culverts and storm sewers. The Port of Seattle is constructing a

large holding pond northwest of the Seattle-Tacoma Airport. For the most part, man-made drainage systems are incomplete and depend upon the natural system for final transport of storm-water. These partial systems often create erosion and water-quality problems.

It is quite obvious that within this predominately residential area, streams are important recreational and aesthetic assets. The stream is used, in part however, as a dump by thoughtless individuals in both residential and commercial areas. This careless action destroys a potentially valuable and attractive amenity in both the social and natural environment.

DRAINAGE PROBLEMS

Major problems in the Miller Creek sub-area are wide-spread, existing not only along the creek (flooding, sedimentation), but also in natural sink or land depression areas located some distance from the natural drainage course. It is significant to note that the problems that presently exist are of a magnitude similar to those anticipated for the year 2000. This is because the projected change in percent imperviousness from present conditions to future conditions is insignificant.

Flooding, ponding, soil erosion and sedimentation problems are distributed over the entire sub-area, but are most severe near the main channel of Miller Creek and in the lower reaches of the stream. Tub Lake has received oil seepage from an old dump site. Reported property damages obtained from local agencies placed the average annual loss for Miller Creek sub-area at $40,440.

The results of hydrologic analysis indicate no significant difference between the Comprehensive and Corridor Land Use Plans. Therefore, the drainage alternatives presented herein are applicable to both plans.

BASIC ISSUES AND STATUS OF DRAINAGE PLANNING

The planning agencies that would plan and eventually take action to alleviate or minimize the above mentioned problems consist, in part, of the jurisdictional agencies in the Miller Creek sub-area plus the State Highway Department which has constructed, and may eventually extend freeways in the sub-area. The Port of Seattle conducted a study of Miller and Des Moines Creeks, in which the water quality, biological conditions, and hydrologic capacities of the two streams were investigated.

King County has a comprehensive drainage plan for Miller Creek that has been stopped by a citizen suit contending that the environmental damage is unacceptable.

At a Miller Creek RIBCO Community Meeting, November, 1973, various alternative methods to alleviate flooding in the Miller Creek sub-area were discussed. The following five general alternatives were presented:

(1) continuation of present trends, (2) storm water diversion facilities, (3) flood-plain management, (4) channelization, and (5) watershed management.

Of the five alternatives presented, watershed management was selected as the most favorable alternative. Storm water diversion facilities, continuation of present trends, flood plain management, and channelization were rejected.

In view of the above preference, the alternatives considered for this sub-area are quite similar.

Staff members from the King County Public Works Department, Hydraulics Division, and representatives of the Citizens Stream Advisory Committee have reviewed the initial alternative plans for drainage developed by this RIBCO Study for the Miller Creek sub-area. A third alternative has been developed with suggestions received from the City of Normandy Park and the Water Quality/Drainage Committee of the Sea-Tac Communities Plan.

ALTERNATIVE PLANS FOR PROPOSED DRAINAGE CONTROL

The existing drainage system of the Miller Creek sub-area as described by local agencies, was evaluated by computer simulation that applied the region's 10-year storm to P.S.G.C. year 2000 land use. Drainage problems thus identified were analyzed and possible solutions provided in development of alternative plans for drainage control as described below.

ALTERNATIVE PLAN I

General Concepts

This alternative makes use of seven holding ponds, combined with limited improvements along the creek to accommodate flows in excess of the capacity of the natural stream. From computer model simulation, it was found that the holding ponds alone, with no channel improvements, did not have sufficient capacity to prevent major flooding along the creek. Therefore, both holding ponds and improved channel sections are necessary to alleviate flooding.

Major Features

Major features of this system can be grouped into three broad categories: holding ponds, enlarged conduit capacities (or parallel pipelines), and enlarged natural channel capacities. Rather than "rebuild" the existing natural channels to accommodate flows, a diversion structure and pipeline were used. In this manner, flow exceeding the capacity of an existing natural reach of the creek will be diverted to a parallel concrete pipeline, which will later discharge the excess flow into the creek where the capacity of the natural creek will be sufficient to handle the total flow. Use of combined flows was selected primarily because the citizens of Miller Creek

voted unanimously against channelization (concrete lining and rip-rapping) of natural stream courses. A second reason this limited diversion was selected was because the natural channel, in reaches located northwest of the Seattle Tacoma Airport, would need to widened 40 to 60 feet. This widening, required to accommodate the design flows, would require the removal of homes or other structures.

Cost

Cost for Alternative Plan I is estimated to be $4,700,000.

ALTERNATIVE PLAN II

General Concept

This alternative is identical to Alternative Plan I, previously mentioned, except that a major trunkline (78 inch conduit) intercepts flow in the "five corners" area of Burien, and carries it southwesterly along Sylvester Road to Puget Sound.

Major Features

Most features of this alternative are the same as those of Alternative Plan I, except, that instead of directing flow from the "five corners" area into Miller Creek, the flow is directed into a trunkline which conveys the flow to Puget Sound. By diverting 335 cfs from Miller Creek, the reaches of Miller Creek to be improved southwesterly of 1st Ave. So. need not be sized as large as designed for Alternative Plan I.

Cost

The cost for Alternative Plan II is estimated to be $6,300,000.

ALTERNATIVE PLAN III

General Concept

This alternative is identical to Alternative Plan II, previously mentioned, except that the Port Pond is increased in capacity, two additional holding ponds are located downstream from the Port Pond, and the most downstream reach of Miller Creek utilizes flood plain zoning. The two additional holding ponds not only reduce the peak flows in the lower portion of Miller Creek, but also eliminate the need for diversion pipelines and enlarged conduits downstream from the Port Pond to the intersection of First Avenue South.

The number of parallel pipelines required along Miller Creek between Arbor Lake and the Port Pond, especially the reach downstream of the Freeway (State Highway 509) could be reduced by utilizing holding

ponds along or adjacent to the creek. To more fully investigate the possibility of additional holding ponds in this reach, the availability of appropriate land for holding pond sites would have to be studied.

Major Features

Most of the features for this alternative are the same as those of Alternative II, except for the following changes or additions:

1. The Port Pond (Element 41) is increased in capacity from its present total capacity of 32 AF to a total capacity of 160 AF.

2. A 3 AF holding pond (Element 29) is to be located about 0.7 mile downstream from the Port Pond.

3. A 4 AF holding pond (Element 44) is to be located about 1-1/2 miles downstream from the Port Pond.

4. The diversion to conduit at the mouth of Miller Creek, as shown in Alternative II, will not be required because the lands immediately adjacent to the creek will be allowed to flood for short durations during heavy storms.

Cost

The cost for this alternative is estimated to be $6,900,000.

PEAK-FLOW COMPARISONS

The following table indicates 10-year peak flows with existing facilities and land use, and with alternative drainage management solutions for the year 2000.

COMPARISON OF 10-YEAR PEAK FLOWS
(Cubic Feet Per Second)

Location	Existing Land Use: Existing Facilities*	Existing Facilities*	Alternative Plan I	Alternative Plan II	Alternative Plan III
S. 136th St. & SR509	165	165	250	250	250
SR 518	200	200	350	350	350
S. 160th St.	70	70	240	240	40

* Flows shown are lower than Alternative Plan flows because of restrictions in streamways which create uncontrolled flooding. Alternative Plans have been formulated to eliminate all flooding.

Location	Existing Facilities*	Existing Facilities*	Alternative Plan I	Alternative Plan II	Alternative Plan III
1st Ave. S.	480	480	520	310	120
Shorebrook Drive	110	110	160	160	160
Mouth	100	100	-	-	440
Sylvester Rd. Trunkline	-	-	-	260	260

ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE PLANS

Field inspections were made to judge the applicability of the suggested alternative plans for this sub-area. This procedure was followed throughout the RIBCO Study for development of alternative plans for the various regional sub-basins. The inspections were based upon the alternative evaluation procedure which identified 34 unique criteria grouped in general categories as follows: 1) Effectiveness, 2) Human Values, 3) Environmental Factors, 4) Implementation, and 5) Resource Requirements. The various structural elements in the alternative plans were checked against the appropriate criteria and the various non-structural elements were reviewed for their relationship to existing and probable future developments. The criteria rating total for Alternative Plan I, which employs storage, diversion, and new conduit, was a negative 12 on a scale ranging from positive 108 to negative 108. The total evaluation rating for Alternative Plan II, which employs storage, diversion, new conduit, and a major trunkline, was a negative 14. The total evaluation rating for Alternative Plan III, which employs maximum storage, limited streamside diversion, new conduit and a major trunkline, was a positive 8.

Alternatives I and II received negative ratings for effectiveness, although both are believed to be successful for controlling flood damage within the design level storm. Alternative Plan III received a positive rating for effectiveness based in part on erosion control potential and general reliability. All three alternatives allow development adjacent to the streams, and therefore may result in serious consequences to stream side properties due to flooding beyond the design level storm. All three alternatives present rather difficult maintenance problems. Reliability of Alternatives I and II is questionable due to the extensive reliance on diversion systems.

All three alternative plans received positive ratings for promotion of human values as they will allow maximum development of land within the sub-area and they do not require displacement of people. None of the alternatives, however, provide multiple use potential nor would they significantly enhance community cohesion through the preservation or designation of broad greenways.

Negative ratings were received by both Alternatives I and II for environmental factors. The primary basis for this rating was the extensive alteration of the natural system as well as the potential effects upon wildlife and vegetation. Alternative Plan III received a positive rating for environmental factors due to minimal alteration of the natural system. All three alternative plans should enhance aquatic life potential as well as improve water quality and assure low flow conditions.

The implementation possibility of all alternative plans is judged to be relatively difficult because of the degree of jurisdictional cooperation necessary, the significant land acquisition involved and the necessity to accomplish drainage control within this sub-area in the immediate future.

All plans incorporate, to some degree, drainage concepts supported by the general public in the sub-area. Negative ratings for resource requirements were given to all alternative plans because of the high energy and material requirements necessary, as well as the extensive capital outlay needed to accomplish either alternative plan.

One important element in all alternatives is the proposal to use storage areas in the upper sub-area. This treatment, if it is to be part of the chosen alternative for Miller Creek sub-area, should be implemented as an early organized effort. Any one of the holding pond sites designated in the alternative plans that is eliminated by development will necessitate the use of a more structural treatment than the alternative plans can accommodate. This issue should be brought to the attention of all citizens and their local agencies.

The extensive use of diversion pipeline in the natural areas of the stream, as contemplated in both Alternative Plans I and II, would need to be accomplished with extreme care. The diversion pipelines do not impact the stream channel per se, but could have potentially harmful effects upon the wildlife and natural vegetation typical of the natural stream course along which they must pass.

CONCLUSIONS

Alternative Plan III is superior to either Alternative Plan I or II, because of its ability to control stream flow without impacting natural channels or streamways. Benefits received from the major trunkline diversion alone as suggested in Alternative Plan II are relatively insignificant when compared to the tremendous cost for this facility. The designation of necessary storage areas must be accomplished if any of the alternative plans are to work effectively and if the sub-area is to avoid channelization or diversion of the entire stream course.

King County, the Port of Seattle, and the City of Normandy Park should establish an effective agreement on a master drainage plan, that incorporates the conditions of Alternative Plan III. Both agencies then should move to implement those portions of the plan falling within their own jurisdiction.

The basic issue appears to be which local agency or agencies will have jurisdiction and responsibility for control of urban drainage and related flood damage problems in the Miller Creek sub-area. The County should have responsibility for control of drainage and flood damage, and the City of Normandy Park and the Port of Seattle should participate in drainage master plan development and execution of necessary solutions within their jurisdiction.

EARLY ACTION

In addition to the immediate need for development of a drainage master plan and designation of jurisdictional leadership within this demonstration area, certain physical features of the alternative plans, presented herein, appear to be generally applicable to any drainage plan which may be forthcoming as well as both suitable and desirable for early implementation within the next ten-year period. These features are presented in the three categories previously defined.

FACILITY RECOMMENDATIONS

The business district in Burien has experienced frequent flooding and it is recommended that the present inadequate drainage system be improved.

The second, and equally important, recommendation is that of preserving the existing natural drainage system. Early implementation in this regard should be to construct holding ponds, or improve existing lakes and holding ponds.

The following specific early implementation items encompass the above described recommendations, and include two additional recommendations to correct reported drainage problems.

Category I - Common Alternative Elements (as per Alternative I)

Element Number	Proposed Facility	Estimated Capital Cost
41	holding pond, 39.5 Acre-Feet	$380,000
205	holding pond outlet	11,000
55	holding pond, 7 Acre-Feet	47,000
200	holding pond outlet	5,000
64	holding pond, 2.8 Acre-Feet	35,000
204	holding pond outlet	7,000
221	holding pond, 3.5 Acre-Feet	18,000
206	holding pond outlet	11,000
34	holding pond, 110 Acre-Feet	44,000
207	holding pond outlet	4,000
	TOTAL	$562,000

Category II - Alternative Elements Common in Scope

None

Category III - Response to Reported Drainage Problems

Element Number	Proposed Facility	Estimated Capital Cost
201	holding pond, 5.5 Acre-Feet	$ 35,000
202	30" pipe - 4500'	240,000
128	42" pipe - 550'	43,000
158	42" pipe - 650'	51,000
220	24" pipe - 900'	37,000
219	30" pipe - 2600'	139,000
218	36" pipe - 1800'	117,000
217	42" pipe - 2400'	189,000
216	30" pipe - 3200'	171,000
215	36" pipe - 500'	33,000
214	60" pipe - 1000'	119,000
213	33" pipe - 1000'	59,000
212	54" pipe - 3400'	359,000
211	42" pipe - 1500'	118,000
	TOTAL	$1,710,000

EVALUATION MATRIX

MILLER CREEK DEMONSTRATION AREA

EFFECTIVENESS

ALTERNATIVES	SUB TOTAL	Use of existing facilities (1)	System reliability (4)	System maintainability (3)	System flexibility (2)	Flood damage reduction (4)	Consequences of overcharge (4)	Erosion and sedimentation control (4)	Cost benefits ranking (2)
I	-4	+1 / +1	-1 / -4	-1 / -3	+1 / +2	+1 / +4	-1 / -4	0	0
II	-6	+1 / +1	-1 / -4	-1 / -3	+1 / +2	+1 / +4	-1 / -4	0	-1 / -2
III	+2	+1 / +1	0	-1 / -3	+1 / +2	+1 / +4	-1 / -4	+1 / +4	-1 / -2

HUMAN VALUES

ALTERNATIVES	SUB TOTAL	Urban quality (aesthetics) (4)	Effect on land use (2)	Displacement of people (2)	Educational value (1)	Community cohesion (3)	Multiple use potential (3)	Public health and safety (4)
I	+5	0	+1 / +2	+1 / +2	+1 / +1	0	0	0
II	+5	0	+1 / +2	+1 / +2	+1 / +1	0	0	0
III	+7	+1 / +4	+1 / +2	0	+1 / +1	0	0	0

ENVIRONMENTAL FACTORS

ALTERNATIVES	SUB TOTAL	High flow conditions (4)	Alteration of natural system (4)	Effects on groundwater (4)	Low flow conditions (4)	Water quality (4)	Construction disruption (2)	Effects on wildlife (4)	Effects on aquatic life (4)	Effects on vegetation (4)
I	- 2	0	-1 / -4	0	+1 / +4	+1 / +4	-1 / -2	-1 / -4	+1 / +4	-1 / -4
II	- 2	0	-1 / -4	0	+1 / +4	+1 / +4	-1 / -2	-1 / -4	+1 / +4	-1 / -4
III	+12	0	0	0	+1 / +4	+1 / +4	0	0	+1 / +4	0

IMPLEMENTATION

ALTERNATIVES	SUB TOTAL	Legislative requirements (4)	Jurisdictional (4)	Land acquisition (2)	Public acceptance (4)	Financing (4)	Effects of no action (3)
I	-5	0	-1 / -4	-1 / -2	+1 / +4	0	-1 / -3
II	-5	0	-1 / -4	-1 / -2	+1 / +4	0	-1 / -3
III	-5	0	-1 / -4	-1 / -2	+1 / +4	0	-1 / -3

RESOURCE REQUIREMENTS

ALTERNATIVES	SUB TOTAL	Energy (3)	Materials (3)	Land (2)	Capital (2)	RATING TOTAL
I	-6	-1 / -3	-1 / -3	+1 / +2	-1 / -2	-12
II	-6	-1 / -3	-1 / -3	+1 / +2	-1 / -2	-14
III	-8	-1 / -3	-1 / -3	0	-1 / -2	+ 8

RUNOFF QUALITY SUMMARY
MILLER CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 5 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth of Creek	Present	100	9	2.1×10^5	.3	.6	.1
	I	810	11	3.2×10^5	.4	.8	.1
	II**	550	10	3.3×10^5	.4	.8	.1
	III	440	10	3.1×10^5	.4	.8	.1
1st Avenue	Present	410	8	2.1×10^5	.3	.6	.1
	I	520	12	3.0×10^5	.4	.9	.1
	II	310	11	3.3×10^5	.4	1.2	.1
	III	120	10	3.3×10^5	.4	1.2	.1
Renton Three Tree Point Road South	Present	70	7	1.4×10^5	.2	.5	.1
	I	240	9	2.7×10^5	.3	.7	.1
	II	240	9	2.7×10^5	.3	.7	.1
	III	40	9	2.7×10^5	.3	.7	.1
South 136th St.	Present	160	3	8.0×10^4	.1	.2	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.
** Maximum flow in diversion trunkline = 260 cfs.

RUNOFF QUALITY SUMMARY
MILLER CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 5 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
South 136th St.	I	250	6	2.4×10^5	.2	.4	.1
	II	250	6	2.4×10^5	.2	.4	.1
	III	250	6	2.4×10^5	.2	.4	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in *mg/liter* except total *coliform which* is *in* MPN/100 *ml*.

RUNOFF QUALITY SUMMARY
MILLER CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
Mouth of Creek	Present	100	26	6.3×10^5	.8	1.9	.2
	I	810	33	9.6×10^5	1.2	2.5	.2
	II**	550	29	9.8×10^5	1.1	2.3	.2
	III	440	25	8.0×10^5	1.0	2.1	.2
1st Avenue	Present	410	24	6.4×10^5	.8	1.8	.2
	I	520	36	9.1×10^5	1.3	2.7	.3
	II	310	32	1.0×10^6	1.1	2.5	.3
	III	120	30	1.0×10^6	1.0	2.3	.3
Renton Three Tree Point Road South	Present	70	19	4.3×10^5	.5	1.6	.2
	I	240	26	8.0×10^5	.9	2.1	.2
	II	240	26	8.0×10^5	.9	2.1	.2
	III	40	25	8.0×10^5	.9	2.1	.2
South 136th St.	Present	160	5	1.8×10^5	.2	.4	.1

Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.
** Maximum flow in diversion trunkline = 260 cfs.

RUNOFF QUALITY SUMMARY
MILLER CREEK DEMONSTRATION AREA

BASED UPON A 10-YEAR STORM PRECEDED BY 15 DAYS WITH LITTLE OR NO RAINFALL#

LOCATION	ALTERNATIVE PLAN	PEAK FLOW (cfs)	CONCENTRATION AT PEAK FLOW*				
			BOD	TOTAL COLIFORM	NH_3	$NO_2 + NO_3$	PO_4
South 136th St.	I	250	17	7.2×10^5	.7	1.3	.1
	II	250	17	7.2×10^5	.7	1.3	.1
	III	250	17	7.2×10^5	.7	1.3	.1

\# Less than a total of 0.5 inches of rainfall in any one day.
* Concentrations in mg/liter except total coliform which is in MPN/100 ml.

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Miller Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
60	Pipe	12"	300'			Parallel Pipe	36"	$20,000
59	Pipe	12"	300'			Parallel Pipe	36"	$20,000
58	Pipe	36"	280'			Parallel Pipe	42"	$22,000
55	None					Holding Pond	7 AF 2.3 acres	$47,000
200	None					Pipe	27" 100'	$5,000
53	Pipe	30"	100'			Parallel Pipe	30"	$5,000
52	Pipe	42"	700'			Parallel Pipe	36"	$46,000
51	Pipe	54"	2,600'			Parallel Pipe	42"	$204,000
201	None					Holding Pond	5.5 AF .9 acres	$35,000
202	None					Pipe	30" 4,500'	$240,000
128	Pipe	36"	550'			Parallel Pipe	42"	$43,000
158	Pipe	36"	650'			Parallel Pipe	42"	$51,000
140	Channel	5'	1,200'	3:1	4.5'	Diversion Pipe	48"	$109,000
140	None					Inlet/ Outlet	To 48"	$7,000
138	Channel	3.5'	800'	1.5:1	3'	Diversion Pipe	30"	$43,000
138	None					Inlet/ Outlet	To 30"	$4,000
50	Channel	3.5'	1,700'	1.5:1	3'	Diversion Pipe	48" including inlet/ outlet struc.	$162,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub Basin Miller Creek Demonstration Area

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
136	Pipe	24"	100'			Parallel Pipe	54"	$11,000
135	Channel	3.5'	200'	1.5:1	3'	Diversion Pipe	48"	$18,000
134	Pipe	48"	100'			Parallel Pipe	48"	$9,000
133	Channel	3.5'	250'	1.5:1	3'	Diversion Pipe	48"	$23,000
49	Channel	5.1'	600'	1:2 1:1	3.5'	Diversion Pipe	48"	$55,000
49	None					Inlet/ Outlet	To 48"	$7,000
131	Culvert	9.8'	246'	0	7'	Culvert	Extension of 84" culvert to Port Pond (500')	$54,000
65	Channel	2'	700'	.5:1	2'	Diversion Pipe	30"	$37,000
65	None					Inlet/ Outlet	To 30"	$4,000
156	Pipe	24"	100'			Parallel Pipe	36"	$7,000
157	Channel	2'	1,000'	.5:1	2'	Diversion Pipe	30"	$53,000
64	None					Holding Pond	2.8 AF 1.4 acres	$35,000
204	None					Pipe	36" 100'	$7,000
66	Pipe	24"	100'			Parallel Pipe	30"	$5,000
73	Pipe	18"	1,000'			Parallel Pipe	30"	$53,000
40	Pipe	18"	100'			Parallel Pipe	36"	$7,000
67	Channel	6'	1,000'	.5:1	1'	Diversion Pipe	42"	$79,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Miller Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	PROPOSED FACILITIES TYPE		ESTIMATED CAPITAL COST
67	None					Inlet/ Outlet	To 42"	$6,000
41	Holding Pond	18.5 AF (active)				Holding Pond	39.5 AF (active)	$380,000
205	None					Pipe	54" (throttled) 100'	$11,000
48	Channel	11'	3,200'	2.5:1 1.4:1	2.6'	Diversion Pipe	36" 320'	$21,000
48	None					Inlet/ Outlet	For 36"	$6,000
29	Channel	9'	350'	1.0:1 1.7:1	1.6'	Diversion Pipe	54"	$37,000
45	Channel	4'	3,000'	2:1	2'	Diversion Pipe	60"	$356,000
45	None					Inlet/ Outlet	For 60"	$9,000
44	Culvert	4'	100'	0	4'	Parallel Pipe	30"	$5,000
43	Channel	7'	600'	1:1 2:1	2.3'	Diversion Pipe	54"	$63,000
43	None					Inlet/ Outlet	To 54"	$8,000
42	Pipe	72"	100'			Parallel Pipe	84"	$18,000
214	None					Pipe	60" 1,000'	$119,000
211	None					Pipe	42" 1,500'	$118,000
215	None					Pipe	36" 500'	$33,000
216	None					Pipe	30" 3,200'	$171,000
212	None					Pipe	54" 3,400'	$359,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I   Sub-Basin Miller Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
217	None					Pipe	42" 2,400'	$189,000
218	None					Pipe	36" 1,800'	$117,000
213	None					Pipe	33" 1,000'	$59,000
219	None					Pipe	30" 2,600'	$139,000
220	None					Pipe	24" 900'	$37,000
211-220	None					Inlets	Variety of inlets, @ 500' intervals 35 total	$52,000
221	None					Holding Pond	3.5 AF 1.2 acres	$18,000
206	None					Pipe	54" 100'	$11,000
34	None					Holding Pond	110 AF 37 acres	$44,000
207	None					Pipe	24" 100'	$4,000
130	Pipe	36"	2,100'	-	-	Parallel Pipe	30"	$112,000
129	Culvert	7'	570'	0	2.5'	Parallel Pipe	54"	$60,000
25	Channel	12.5'	800'	2:1 3:1	2.5'	Diversion Pipe	72"	$118,000
25	None					Inlet/ Outlet	To 72"	$11,000
24	Channel	7'	1,000'	3:1	2'	Diversion Pipe	Two-60"	$237,000
208	None					Holding Pond	16.5 AF 8.4 acres	$23,000
209	None					Pipe	15" 2,000'	$50,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative I Sub-Basin Miller Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
152	Pipe	36"	700'	-	-	Parallel Pipe	24"	$29,000
151	Pipe	36"	100'	-	-	Parallel Pipe	24"	$4,000
150	Channel	6'	300'	1:1 7:1	1.8'	Diversion Pipe	24"	$12,000
150	None					Inlet/ Outlet	To 24"	$4,000
145	Culvert	2.8'	100'	0	2'	Parallel Pipe	42"	$8,000
83	Culvert	2.8'	150'	0	2'	Parallel Pipe	30"	$8,000
81	Channel	7.7'	1,000'	2:1	1.6'	Diversion Pipe	60"	$119,000
81	None					Inlet/ Outlet	To 60"	$9,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost $4,721,000

Round To $4,700,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Miller Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
60	Pipe	12"	300'			Parallel Pipe	36"	$20,000
59	Pipe	12"	300'			Parallel Pipe	36"	$20,000
58	Pipe	36"	280'			Parallel Pipe	42"	$22,000
55	None					Holding Pond	7 AF 2.3 acres	$47,000
200	None					Pipe	27" 100'	$5,000
53	Pipe	30"	100'			Parallel Pipe	30"	$5,000
52	Pipe	42"	700'			Parallel Pipe	36"	$46,000
51	Pipe	54"	2,600'			Parallel Pipe	42"	$204,000
201	None					Holding Pond	5.5 AF .9 acre	$35,000
202	None					Pipe	30" 4,500'	$240,000
128	Pipe	36"	550'			Parallel Pipe	42"	$43,000
158	Pipe	36"	650'			Parallel Pipe	42"	$51,000
140	Channel	5'	1,200'	3:1	4.5'	Diversion Pipe	48"	$109,000
140	None					Inlet/ Outlet	To 48"	$7,000
138	Channel	3.5'	800'	1.5:1	3'	Diversion Pipe	30"	$43,000
138	None					Inlet/ Outlet	To 30"	$4,000
50	Channel	3.5'	1,700'	1.5:1	3'	Diversion Pipe	48" including inlet/ outlet struc.	$162,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Miller Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
136	Pipe	24"	100'			Parallel Pipe	54"	$11,000
135	Channel	3.5"	200'	1.5:1	3'	Diversion Pipe	48"	$18,000
134	Pipe	48"	100'			Parallel Pipe	48"	$9,000
133	Channel	3.5'	250'	1.5:1	3'	Diversion Pipe	48"	$23,000
49	Channel	5.1'	600'	1:2 1:1	3.5'	Diversion Pipe	48"	$55,000
49	None					Inlet/ Outlet	To 48"	$7,000
131	Culvert	9.8'	246'	0	7'	Culvert	Extension of 84" culvert to Port Pond (500')	$54,000
65	Channel	2'	700'	.5:1	2'	Diversion Pipe	30"	$37,000
65	None					Inlet/ Outlet	To 30"	$4,000
156	Pipe	24"	100'			Parallel Pipe	36"	$7,000
157	Channel	2'	1,000'	.5:1	2'	Diversion Pipe	30"	$53,000
64	None					Holding Pond	2.8 AF 1.4 acres	$35,000
204	None					Pipe	36" 100'	$7,000
66	Pipe	24"	100'			Parallel Pipe	30"	$5,000
73	Pipe	18"	1,000'			Parallel Pipe	30"	$53,000
40	Pipe	18"	100'			Parallel Pipe	36"	$7,000
67	Channel	6'	1,000'	.5:1	1'	Diversion Pipe	42"	$79,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II   Sub Basin Miller Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
67	None					Inlet/ Outlet	To 42"	$6,000
41	Holding Pond	18.5 AF (active)				Holding Pond	39.5 AF (active)	$380,000
205	None					Pipe	54" (throttled) 100'	$11,000
48	Channel	11'	3,200'	2.5:1 1.4:1	2.6'	Diversion Pipe	36" 320'	$21,000
48	None					Inlet/ Outlet	To 36"	$6,000
29	Channel	9'	350'	1.0:1 1.7:1	1.6'	Diversion Pipe	54"	$37,000
45	Channel	4'	3,000'	2:1	2'	Diversion Pipe	60"	$356,000
45	None					Inlet/ Outlet	To 60"	$9,000
44	Culvert	4'	100'	0	4'	Parallel Pipe	30"	$5,000
43	Channel	7'	600'	1:1 2:1	2.3'	Diversion Pipe	54"	$63,000
43	None					Inlet/ Outlet	To 54"	$8,000
42	Pipe	72"	100'			Parallel Pipe	84"	$18,000
210	None					Pipe	84" 10,000'	$1,810,000
211	None					Pipe	42" 1,500'	$118,000
215	None					Pipe	36" 500'	$33,000
216	None					Pipe	30" 3,200'	$171,000
212	None					Pipe	54" 3,400'	$359,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub Basin Miller Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
217	None					Pipe	42" 2,400'	$189,000
218	None					Pipe	36" 1,800'	$117,000
213	None					Pipe	33" 1,000'	$59,000
219	None					Pipe	30" 2,600'	$139,000
220	None					Pipe	24" 900'	$37,000
211-220	None					Inlets	Variety of inlets, @ 500' intervals 35 total	$52,000
221	None					Holding Pond	3.5 AF 1.2 acres	$18,000
206	None					Pipe	42" 100'	$8,000
34	None					Holding	110 AF 37 acres	$44,000
207	None					Pipe	24" 100'	$4,000
130	Pipe	36"	2,100'	-	-	Parallel Pipe	30"	$112,000
129	Culvert	7'	570'	0	2.5'	Parallel Pipe	42"	$45,000
25	Channel	12.5'	800'	2:1 3:1	2.5'	Diversion Pipe	54"	$85,000
25	None					Inlet/ Outlet	To 54"	$9,000
24	Channel	7'	1,000'	3:1	2'	Diversion Pipe	Two-54"	$212,000
208	None					Holding Pond	16.5 AF 8.4 acres	$23,000
209	None					Pipe	15" 2,000'	$50,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative II Sub-Basin Miller Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
152	Pipe	36"	700'	-	-	Parallel Pipe	24"	$29,000
151	Pipe	36"	100'	-	-	Parallel Pipe	24"	$4,000
150	Channel	6'	300'	1:1 7:1	1.8'	Diversion Pipe	24"	$12,000
150	None					Inlet/ Outlet	To 24"	$4,000
145	Culvert	2.8'	100'	0	2'	Parallel Pipe	42"	$8,000
83	Culvert	2.8'	150'	0	2'	Parallel Pipe	30"	$8,000
81	Channel	7.7'	1,000'	2:1	1.6'	Diversion Pipe	60"	$119,000
81	None					Inlet/ Outlet	To 60"	$9,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $6,334,000

Round To: $6,300,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative III   Sub Basin Miller Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
60	Pipe	12"	300'			Parallel Pipe	36"	$20,000
59	Pipe	12"	300'			Parallel Pipe	36"	$20,000
58	Pipe	36"	280'			Parallel Pipe	42"	$22,000
55	None					Holding Pond	7 AF 2.3 acres	$47,000
200	None					Pipe	27" 100'	$5,000
53	Pipe	30"	100'			Parallel Pipe	30"	$5,000
52	Pipe	42"	700'			Parallel Pipe	36"	$46,000
51	Pipe	54"	2,600'			Parallel Pipe	42"	$204,000
201	None					Holding Pond	5.5 AF .9 acre	$35,000
202	None					Pipe	30" 4,500'	$240,000
128	Pipe	36"	550'			Parallel Pipe	42"	$43,000
158	Pipe	36"	650'			Parallel Pipe	42"	$51,000
140	Channel	5'	1,200'	3:1	4.5'	Diversion Pipe	48"	$109,000
140	None					Inlet/ Outlet	To 48"	$7,000
138	Channel	3.5'	800'	1.5:1	3'	Diversion Pipe	30"	$43,000
138	None					Inlet/ Outlet	To 30"	$4,000
50	Channel	3.5'	1,700'	1.5:1	3'	Diversion Pipe	48" including inlet/ outlet struc.	$162,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative III Sub-Basin Miller Creek Demonstration Area

	EXISTING FACILITIES					PROPOSED FACILITIES		
ELEMENT NUMBER	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
136	Pipe	24"	100'			Parallel Pipe	54"	$11,000
135	Channel	3.5"	200'	1.5:1	3'	Diversion Pipe	48"	$18,000
134	Pipe	48"	100'			Parallel Pipe	48"	$9,000
133	Channel	3.5'	250'	1.5:1	3'	Diversion Pipe	48"	$23,000
49	Channel	5.1'	600'	1:2 1:1	3.5'	Diversion Pipe	48"	$55,000
49	None					Inlet/ Outlet	To 48"	$7,000
131	Culvert	9.8'	246'	0	7'	Culvert	Extension of 84" culvert to Port Pond (500')	$54,000
65	Channel	2'	700'	.5:1	2'	Diversion Pipe	30"	$37,000
65	None					Inlet/ Outlet	To 30"	$4,000
156	Pipe	24"	100'			Parallel Pipe	36"	$7,000
157	Channel	2'	1,000'	.5:1	2'	Diversion Pipe	30"	$53,000
64	None					Holding Pond	2.8 AF 1.4 acres	$35,000
204	None					Pipe	33" 100'	$7,000
66	Pipe	24"	100'			Parallel Pipe	30"	$5,000
73	Pipe	18"	1,000'			Parallel Pipe	30"	$53,000
40	Pipe	18"	100'			Parallel Pipe	36"	$7,000
67	Channel	6'	1,000'	.5:1	1'	Diversion Pipe	42"	$79,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative III Sub-Basin Miller Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
67	None					Inlet/ Outlet	To 42"	$6,000
41	Holding Pond	18.5 AF 4.3 acres (active)				Holding Pond	160 AF (active)	$1,600,000
205	None					Pipe	30" 100'	$5,000
210	None					Pipe	84" 10,000'	$1,810,000
211	None					Pipe	42" 1,500'	$118,000
215	None					Pipe	36" 500'	$33,000
216	None					Pipe	30" 3,200'	$171,000
212	None					Pipe	54" 3,400'	$359,000
217	None					Pipe	42" 2,400'	$189,000
218	None					Pipe	36" 1,800'	$117,000
213	None					Pipe	33" 1,000'	$59,000
219	None					Pipe	30" 2,600'	$139,000
220	None					Pipe	24" 900'	$37,000
211-220	None					Inlets	Variety of inlets, @ 500' intervals 35 total	$52,000
221	None					Holding Pond	3.5 AF 1.2 acres	$18,000
206	None					Pipe	42" 100'	$8,000
34	None					Holding Pond	110 AF 37 acres	$44,000

RIBCO URBAN RUNOFF AND BASIN DRAINAGE STUDY

Alternative III Sub-Basin Miller Creek Demonstration Area

ELEMENT NUMBER	EXISTING FACILITIES					PROPOSED FACILITIES		
	TYPE	PIPE DIAMETER OR CHANNEL BOTTOM WIDTH	LENGTH	CHANNEL SIDE SLOPES (Horiz: Vert.)	MAX. DEPTH OF CHANNEL	TYPE		ESTIMATED CAPITAL COST
207	None					Pipe	24" 100'	$4,000
130	Pipe	36"	2,100'			Parallel Pipe	30"	$112,000
25	Channel	12.5'	800'	2:1 3:1	2.5'	Diversion Pipe	24"	$34,000
25	None					Inlet/ Outlet	To 24"	$4,000
208	None					Holding Pond	16.5 AF 8.4 acres	$23,000
209	None					Pipe	15" 2,000'	$50,000
152	Pipe	36"	700'			Parallel Pipe	24"	$29,000
151	Pipe	36"	100'			Parallel Pipe	24"	$4,000
150	Channel	6'	300'	1:1 7:1	1.8'	Diversion Pipe	24"	$12,000
150	None					Inlet/ Outlet	To 24"	$4,000
145	Culvert	2.8'	100'	0	2'	Parallel Pipe	42"	$8,000
83	Culvert	2.8'	150'	0	2'	Parallel Pipe	30"	$8,000
81	Channel	7.7'	1,000'	2:1	1.6'	Diversion Pipe	60"	$119,000
81	None					Inlet/ Outlet	To 60"	$9,000
154	None					Holding Pond	3 AF 1 acre	$100,000
44	None					Holding Pond	4 AF 1 acre	$110,000

The Estimated Capital Cost for each element includes Contractor profit, engineering, legal and contingencies. In addition, land purchase and severance costs are included where land is required. All costs are based upon June 1973 prices.

Total Estimated Capital Cost: $6,922,000

Round To: $6,900,000

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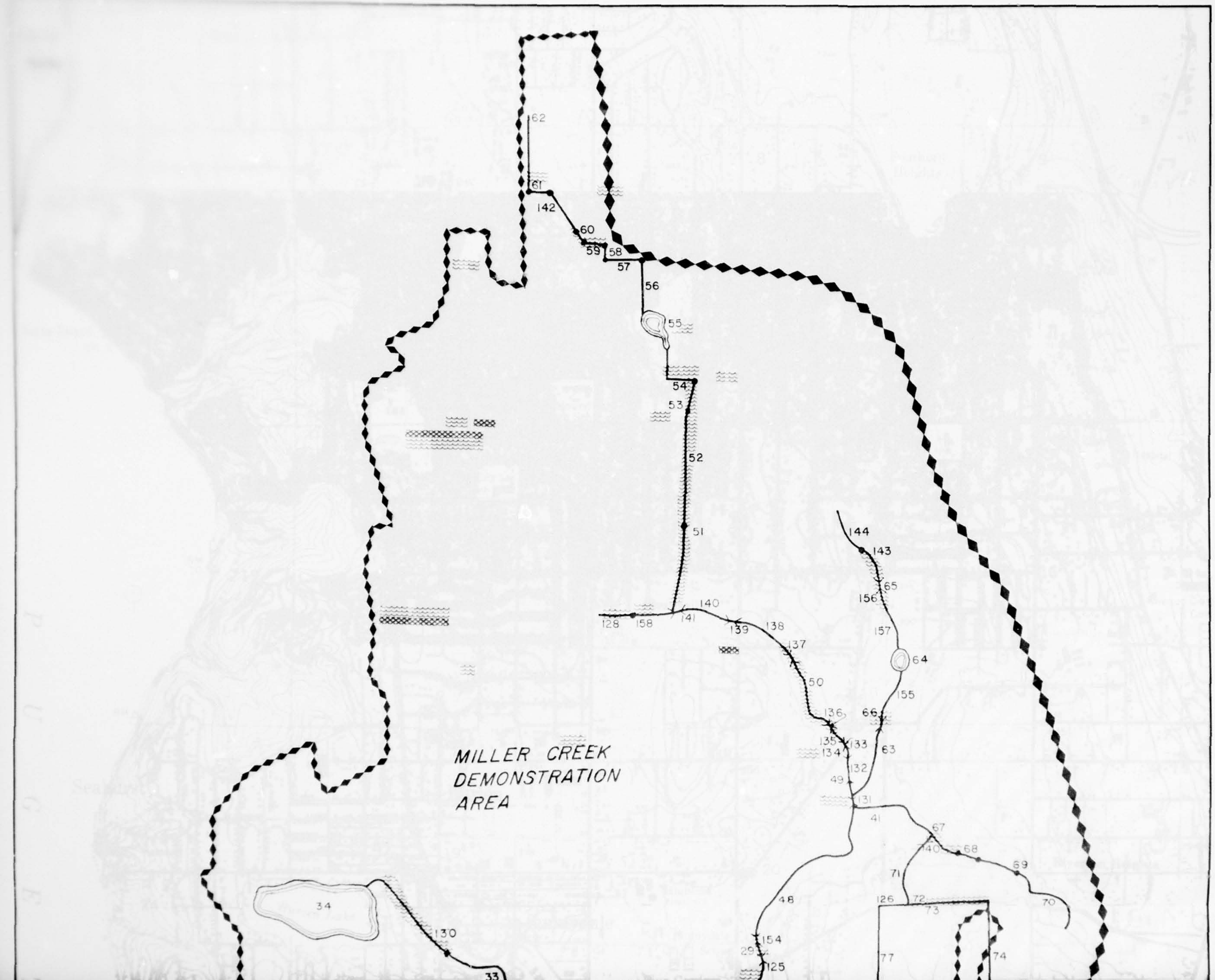

MILLER CREEK
DEMONSTRATION
AREA
62
61
142
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158
141
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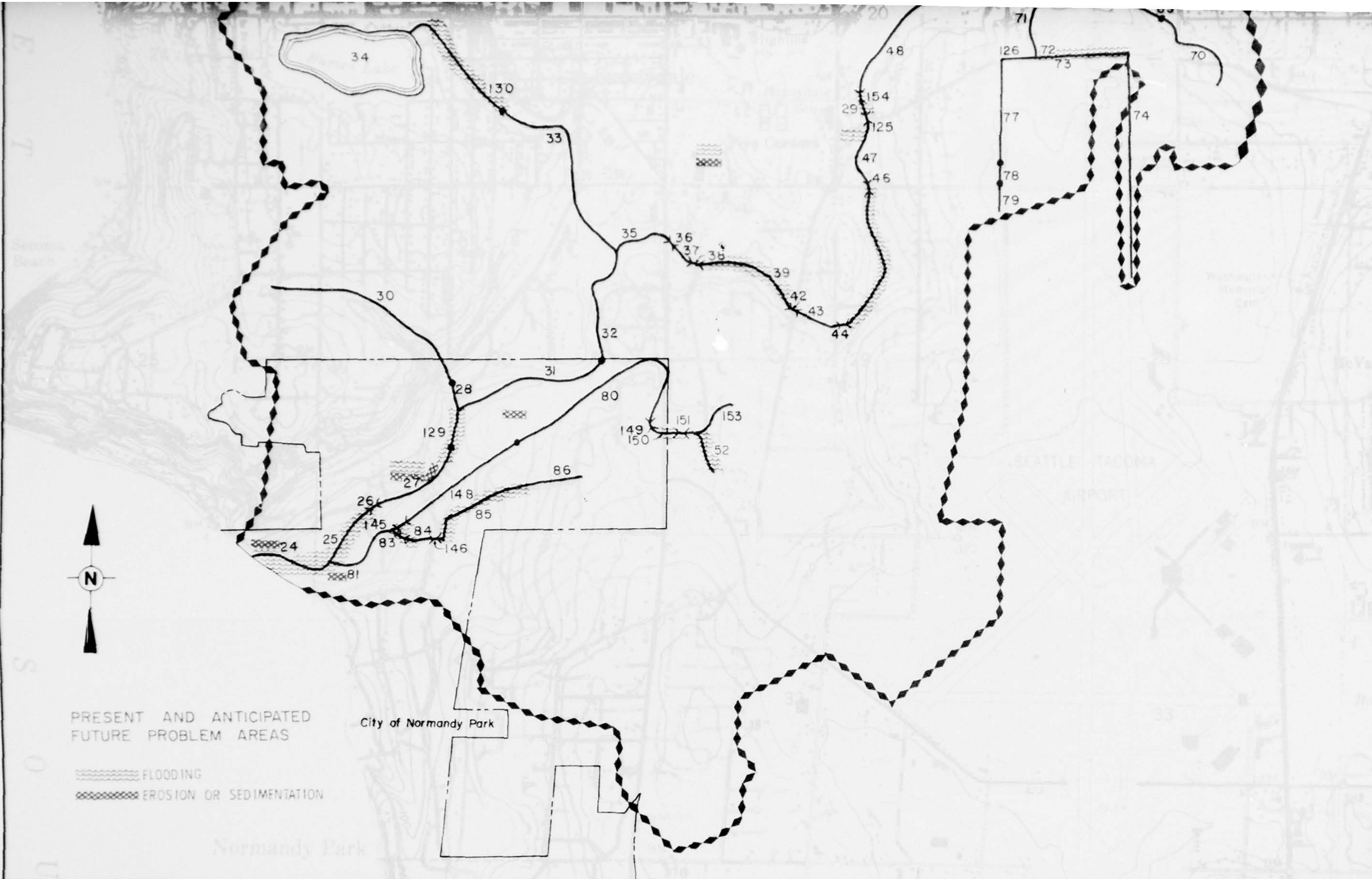
P U G E T



LEGEND

SUB-BASIN BOUNDARY
EXISTING CHANNEL
EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES
1000 500 0 4000
FEET

NO	DESCRIPTION	DATE	APPROVED

REVISIONS

URBAN RUNOFF AND BASIN DRAINAGE STUDY

LOWER PUGET SOUND

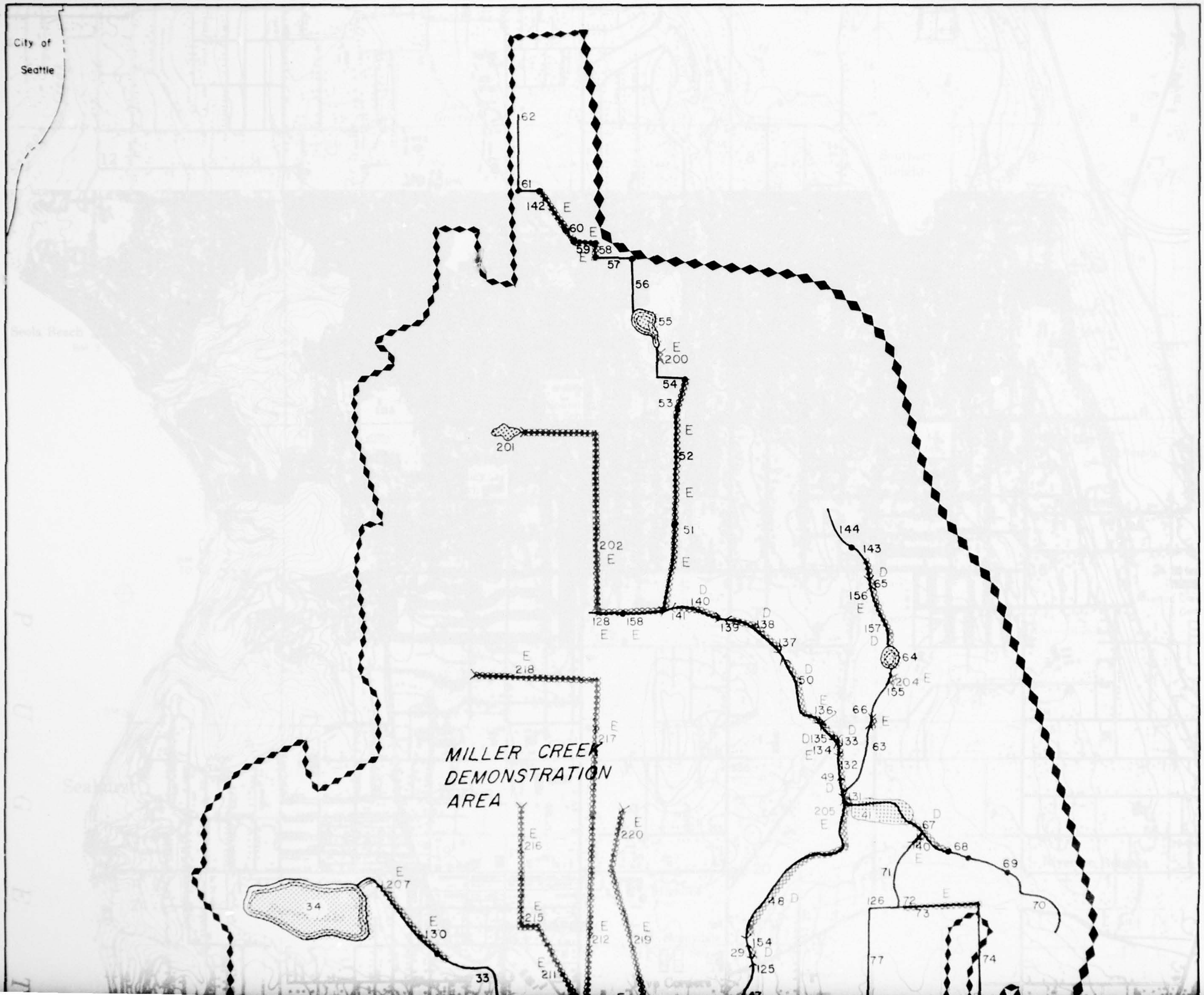
MILLER CREEK DEMONSTRATION AREA

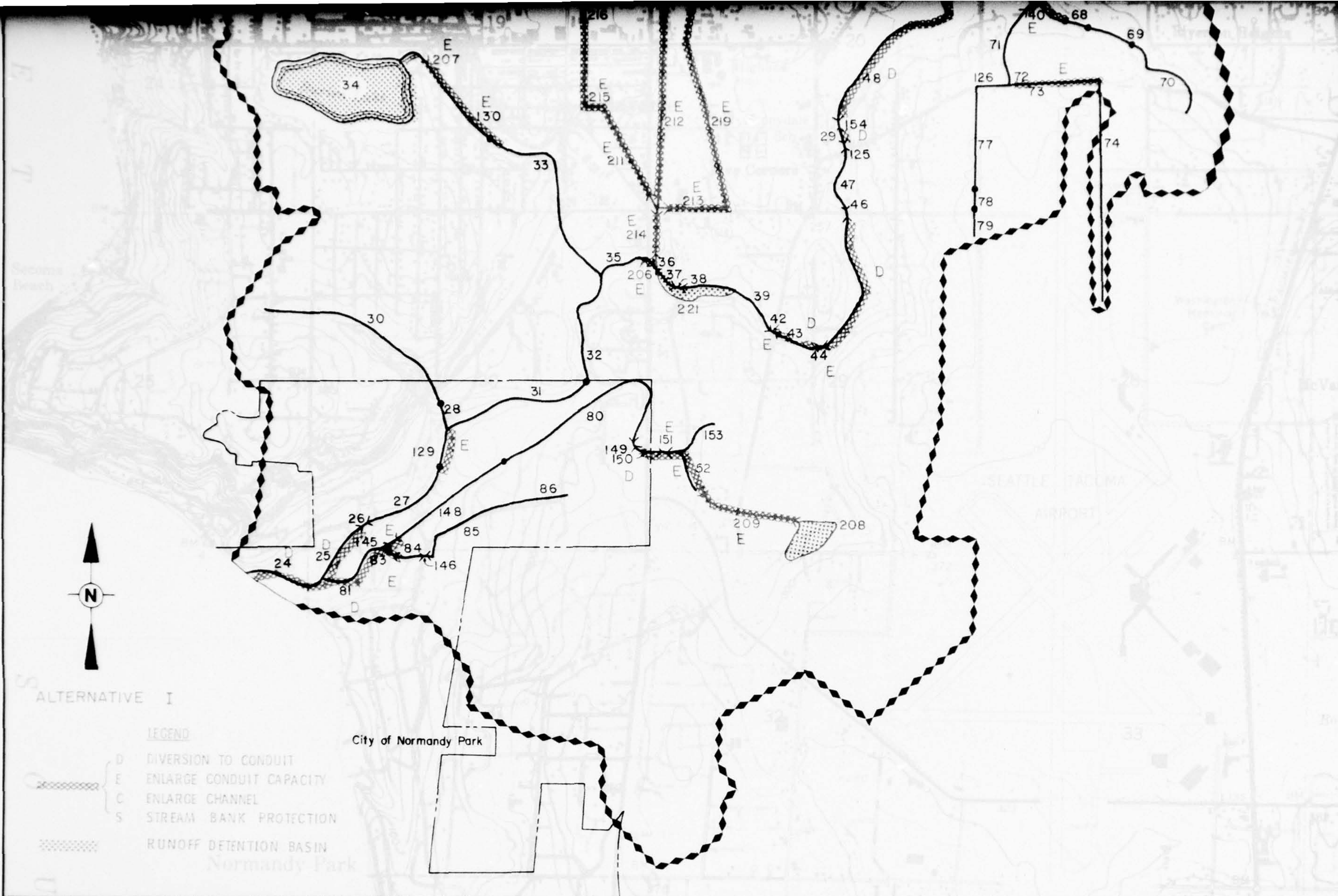
PART OF THE INTEGRATED ENVIRONMENTAL PLAN FOR THE CEDAR AND GREEN RIVER BASINS UNDER THE DIRECTION OF THE RIVER BASIN COORDINATING COMMITTEE (RIBCO) AND THE METRO COUNCIL

KRAMER, CHIN AND MAYO, INC
WATER RESOURCES ENGINEERS, INC
YODER, TROTTER, ORLOB & ASSOCIATES

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DATE AUGUST, 1974 FILE NO E-26.1.161 SHEET 1 OF 1


City of
Seattle
MILLER CREEK
DEMONSTRATION
AREA
P U G E T



LEGEND

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1/2 1/4 0 1
MILES
1000 500 0 4000
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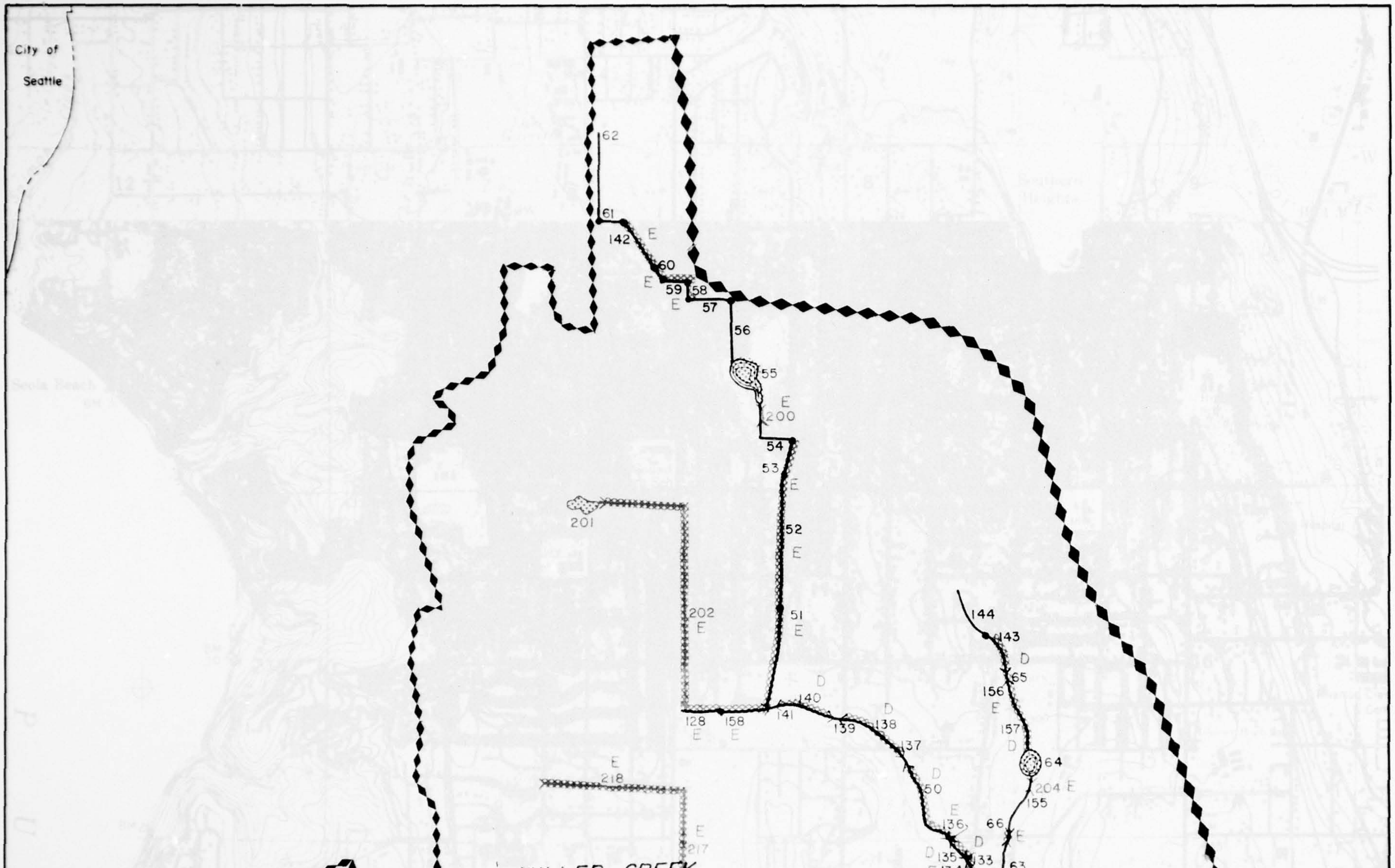
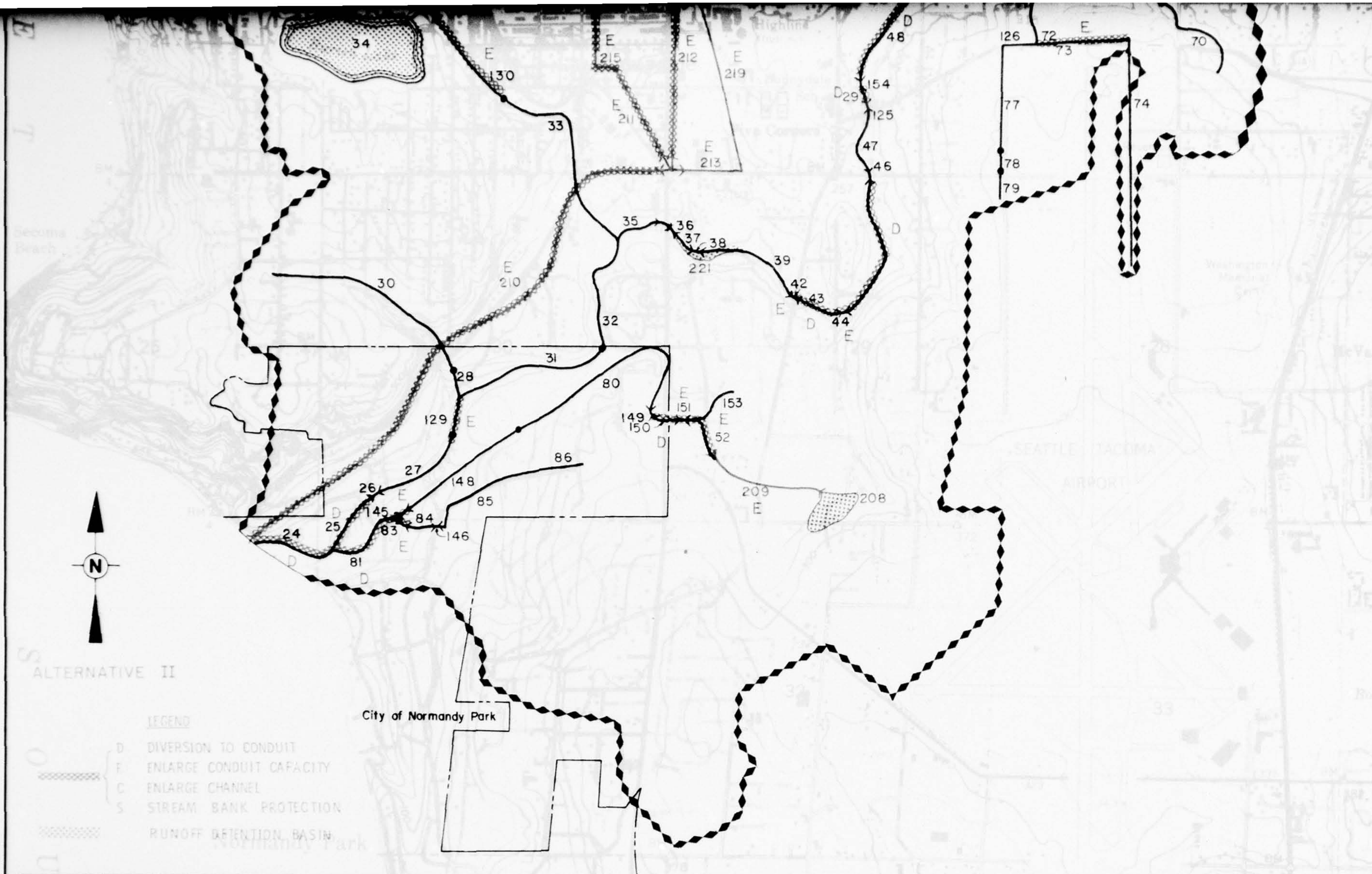

City of Seattle
MILLER CREEK DEMONSTRATION AREA
P U G E T



LEGEND

SUB-BASIN BOUNDARY
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EXISTING CONDUIT
MANHOLE, INLET, OR JUNCTION
CHANNEL OR CONDUIT DESIG. 5
CITY LIMITS
COUNTY (METRO) BOUNDARY
LEVEE
CULVERT
HOLDING POND OR LAKE

1/2 1/4 0 1
MILES

1000 500 0 4000
FEET

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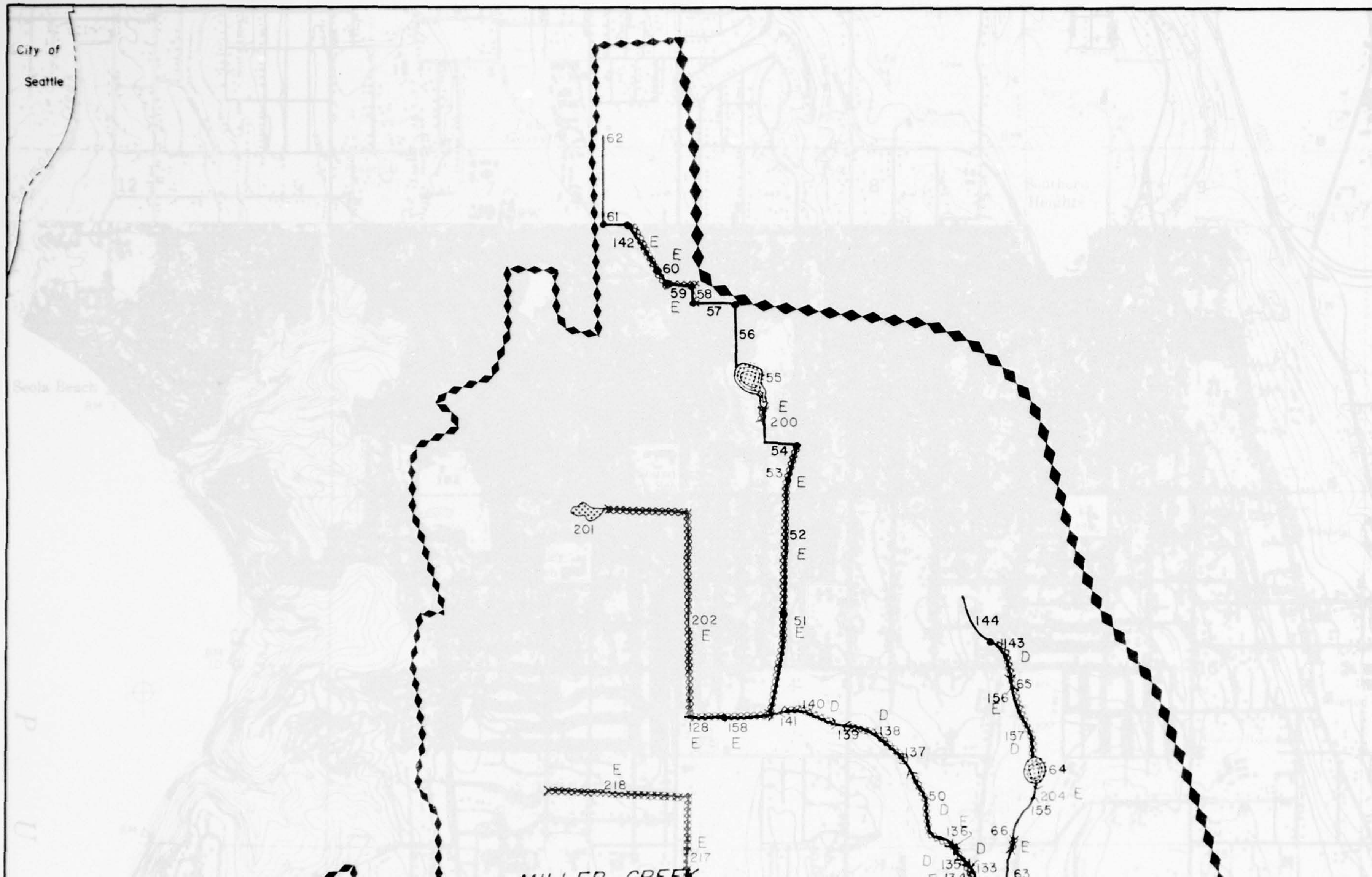
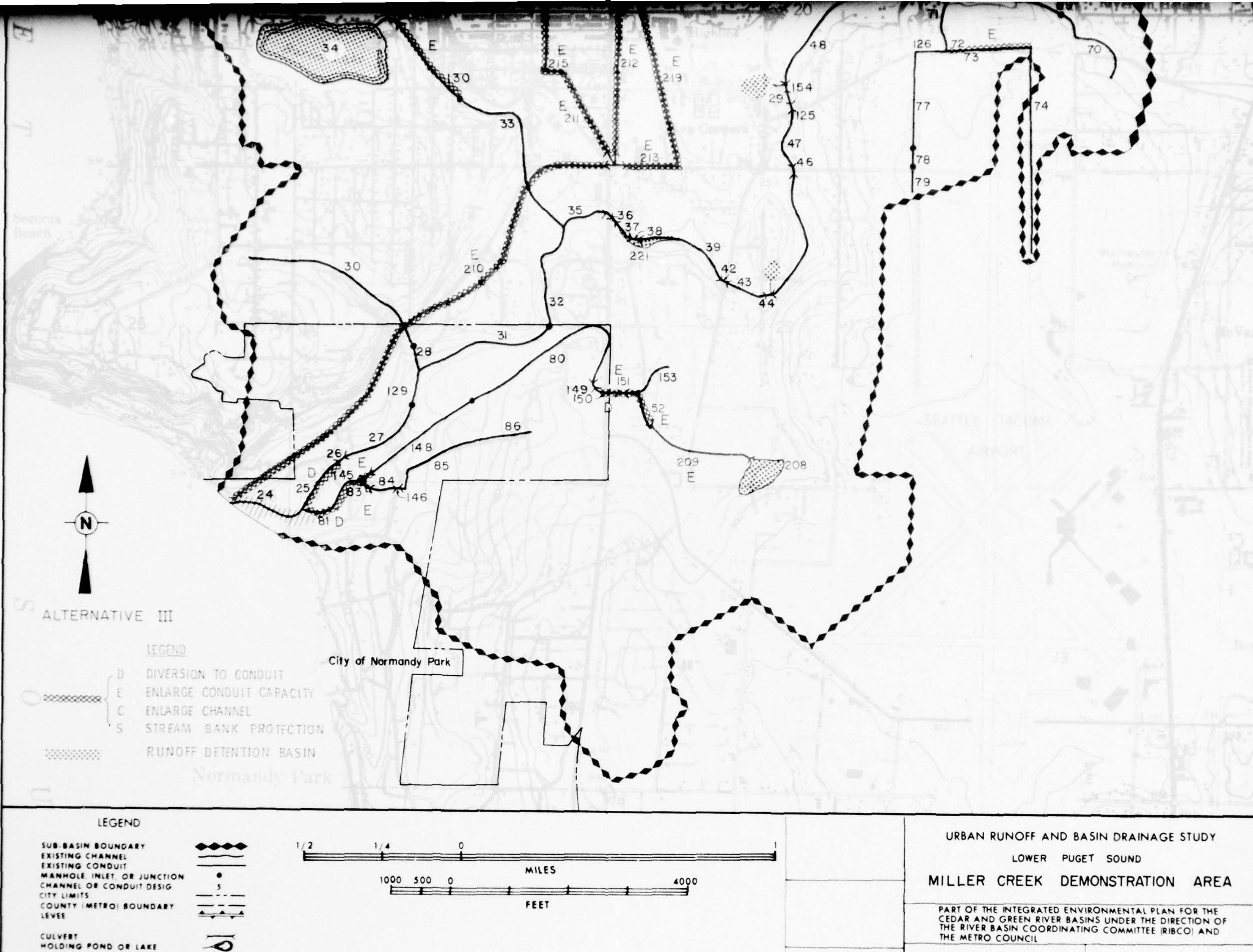


City of
Seattle
MILLER CREEK
DEMONSTRATION
AREA
P U G E T



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MILLER CREEK DEMONSTRATION AREA

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DATE AUGUST, 1974 FILE NO. E-26.1.161 SHEET 1 OF 1

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STATEMENT CONCERNING PORTAGE
TO APPEAR IN SUMMARY REPORT

243. IMPACT OF FINAL HEARING ON PLAN

As a result of the two hearings on the proposed Basin Plan the Coordinating Committee members met and reviewed the testimony. The intense local and congressional opposition is based on the very understandable desire of the inhabitants of the valley not to be displaced from their homes and livelihood. This type of opposition was expected and is typical in water resource projects. It has not been a bar to projects where benefits are realized by others, which, in the judgement of policy makers outweight the disadvantages to those being displaced. However, in the case of this project, no support was expressed by those who stand to benefit from its construction. Accordingly, the coordinating committee concludes that they prefer to forgo the benefits, realizing that the recreation, power and water quality needs that could have been met by the project will go unfulfilled or will be accomplished in some other way, at some greater economic cost. The coordinating committee, therefore further concludes that the project should be deferred from being recommended as part of the early-action program. However, because it was the consensus of the members that Portage is an excellent site for a multiple-purpose reservoir development, and because a large part of the Basin's needs will not be met, additional studies appear warranted. These studies should include possible alternative sites for water-oriented recreation, a smaller scale of recreational development, development of the site by other than the Federal Government, a complete agricultural impact study and possible use for other purposes such as water supply.

244. The State of New York and the several counties of the Genesee Basin have subsequent to the public hearings formed the Genesee Basin Regional Board. This Board should give high priority to the re-evaluation of Portage.

245. The hearings demonstrated that the other recommendations of the proposed Basin Plan were, in general, acceptable to the public. Therefore, the consensus of the Coordinating Committee was to include these items in the early-action plan for recommendation.